SUPPLY CHAIN COORDINATION AND RURAL DEVELOPMENT

CASE STUDIES ON VERTICAL AND HORIZONTAL COORDINATION IN FOOD SUPPLY CHAINS IN SENEGAL AND RWANDA

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Summary

Institutional innovations in food value chains are shaping and affecting the way food is produced and traded in developing countries. There is, however, no consensus yet on the overall welfare implications. The work in this dissertation is built on case studies in Rwanda and Senegal. We focus on vertical and horizontal coordination processes in food supply chains and address three main research gaps. Doing so, we increase the understanding of the multiple dimensions of food value chains, their performance and their development implications.

First, few studies have looked at the indirect effects of increased rural employment in (export) food value chains. Empirical studies mostly focused on the inclusiveness and effectiveness of vertical coordination schemes, especially with regard to contract farming. However, as there is a global trend of increased vertical integration, labor market effects become more important. In chapter 2, we consider a case study in Senegal and analyze the indirect effect of the boom in horticultural exports and the related increase of rural employment on child schooling. The export boom has caused a dramatic increase in female off-farm wage employment in the export companies, which led to increased female bargaining power in the household. We investigate the causal effect of female wage income on primary school enrolment. We develop a collective household model with endogenous bargaining power to show that, if women have higher preferences for schooling than men, the impact of female wage income on school enrolment will be the result of a positive income effect, a negative labor substitution effect and a positive empowerment effect. We also address the question empirically and show that female off-farm wage income has a positive effect on primary school enrolment. For example, female wage employment increases the likelihood of primary school aged children to be enrolled in school with 26% points, an effect that is found to be equally large for both boys and girls. Further, we demonstrate that female empowerment is specifically important for the schooling of girls.

Second, the existing literature mostly focuses on higher-value and global food supply chains, either export chains or chains dominated by FDI and large supermarkets. However, the landscape of food value chains is more diverse than the typical dichotomous distinction between so called ‘modern’ and ‘traditional’ food value chains. In chapter 3, we conduct a value chain analysis of horticultural value chains in Rwanda. We show that a wide variety of horticultural supply chains exist in the country and argue that value chains can be

differentiated beyond the current dichotomy of global (modern) chains versus local (traditional) chains. Processes of modernization, especially value-adding, quality and product differentiation and vertical coordination, also take place in domestic and local chains.

Third, in the context of food value chains the effects of horizontal coordination processes at producer level resulting in the establishment of professional producer cooperatives, have rarely been analyzed. In chapter 4, we analyze the direct effects of participation in cooperatives on the agricultural performance of rural households in Rwanda. Agricultural policies in Rwanda focus on agricultural intensification and increased market orientation of the smallholder farm sector. Cooperatives are seen as key vehicles in this, but little is known about their effectiveness to achieve these goals. Unlike most impact studies that focus on a single cooperative or on multiple cooperatives in a single sub-sector, we explicitly look at the diversity in cooperatives and analyze the role of cooperative structure and organizational differences to explain impact heterogeneity across different cooperatives. We use cross-sectional household data, collected in 2012, to analyze the impact of cooperative membership on different agricultural performance indicators, including indicators on agricultural intensification, market orientation, farm revenue and income. We use several econometric techniques to deal with potential selection bias in estimating the impact of cooperative membership, including a proxy variable method based on a willingness-to-pay-measure and propensity score matching methods. We find that cooperative membership in general has a positive impact on different farm performance indicators. Participation in a cooperative improves market orientation as it increases the share of farm produce sold with 10 to 16% points. Cooperative membership also results in increased agricultural intensification as it increases the value of inputs used with 6 to 8.6 thousand RWF, and the likelihood of using improved seeds, mineral fertilizer, pesticides and irrigation increases with about 21 to 31% points. Cooperative membership further increases gross farm revenue with 37% and net farm income with 25%. However, these effects are driven by specific types of cooperatives. We find the largest effects for cooperatives in which farmers' incentives are least distorted, i.e. cooperatives that focus on joint input acquisition and marketing and cooperatives in which remuneration is individually based. We find no effects for cooperatives that focus on joint production and for cooperatives without individual remuneration.

In chapter 5, we use the Rwandan case study and analyze both inclusiveness and effectiveness of agricultural cooperatives. We estimate mean income and poverty effects of cooperative membership using propensity score matching techniques. Unlike most impact

studies, we look beyond the mean effects and evaluate impact heterogeneity. We analyze heterogeneous treatment effects across farmers by analyzing how estimated treatment effects vary over farm and farmer characteristics and over the estimated propensity score. We find that cooperative membership in general increases income and reduces poverty. We find that farm income increases with about 40 to 45% and total household income with about one fifth to one fourth, and that the likelihood of being poor reduces with 10 to 14% points. We further find that these effects are largest for larger farms and in more remote areas. We find evidence of a negative selection as the impact is largest for farmers with the lowest propensity to be a cooperative member.

Samenvatting

In verschillende ontwikkelingslanden zien we dat de manier waarop voedsel geproduceerd en verhandeld wordt, sterk beïnvloed is door hoe voedselketens georganiseerd zijn. Over de welvaartsimplicaties van deze organisatiestructuren voor rurale landbouwgezinnen bestaan echter (nog) geen eensgezinde conclusies. In dit proefschrift bespreken we horizontale en verticale coördinatieprocessen in voedselketens in Senegal en Rwanda en leveren zo bijkomende argumentatie voor drie lacunes in het huidige onderzoeksveld.

Verticale integratie is een wereldwijde trend in verschillende exportketens en zorgt ervoor dat de effecten van tewerkstelling in exportbedrijven belangrijker worden. In de huidige literatuur analyseren empirische studies voornamelijk het gebruik van landbouwcontracten, een intermediaire vorm van verticale coördinatie. Men onderzoekt welke rurale landbouw-gezinnen zulke landbouwcontracten (kunnen) afsluiten en wat de rechtstreekse effecten hiervan zijn. De indirecte effecten van werkgelegenheid in rurale gebieden is op dit moment nog veel minder onderzocht. Deze effecten ontstaan door een complete verticale integratie van de landbouwproductie waarin bedrijven zowel de productie, verwerking als vermarkting organiseren. In hoofdstuk 2 bekijken we de situatie in Senegal en onderzoeken we of een toename van de werkgelegenheid in de tuinbouwexport een effect heeft op de scholings-participatie van kinderen op het platteland. De stijging van export in tuinbouwproducten uit Senegal en de bijhorende verticale integratie heeft tot een explosieve groei van de werkgelegenheid in rurale gebieden geleid. In de verschillende exportbedrijven worden voornamelijk vrouwen tewerkgesteld wat leidde tot een versterkte onderhandelingspositie van de vrouwen in hun huishouden. In onze studie onderzoeken we of deze tewerkstelling en het bijhorend inkomen een causaal effect heeft op de scholingsparticipatie van kinderen in de basisschool. We ontwikkelen eerst een theoretisch model waarin de onderhandelingspositie van de vrouw als endogeen beschouwd wordt. Aan de hand van dit model tonen we aan dat, áls vrouwen een hogere preferentie hebben dan mannen om hun kinderen naar school te sturen, het uiteindelijk effect van de tewerkstelling van de vrouw op de scholingsparticipatie van de kinderen via drie verschillende effecten verloopt: een positief inkomenseffect, een negatief arbeidssubstitutie-effect en een positief emancipatie-effect. Aanvullend op de theorie voeren we een empirisch onderzoek uit, waarin we vinden dat de tewerkstelling van vrouwen in exportbedrijven een positief effect heeft op de scholingsparticipatie van de kinderen. Meerbepaald stijgt de kans dat kinderen op de lagere school zitten met 26% punten als een

vrouw werkt in een exportbedrijf; dit effect is van dezelfde grootteorde voor jongens en meisjes. We tonen tenslotte ook aan dat het emanciperend effect van de tewerkstelling van de vrouwen van specifiek belang is voor de scholingsparticipatie van meisjes.

Verder richt de bestaande literatuur zich voornamelijk op ‘moderne’ ketens zoals de exportsector, sectoren gedomineerd door multinationals en/of de supermarktsector waarbinnen hoogwaardige landbouwproducten verhandeld worden. In de realiteit zien we echter een meer divers en complex netwerk aan ketens dan het typische dichotome onderscheid tussen zogenaamde 'moderne' en 'traditionele' voedselketens laat vermoeden. In hoofdstuk 3 nemen we de tuinbouwsector in Rwanda onder de loep en tonen aan dat er een breed scala aan diverse ketens bestaat. We stellen ook vast dat verschillende ontwikkelingen die worden gedefinieerd als kenmerken van een moderne keten (zoals het creëren van toegevoegde waarde, zich differentiëren met kwaliteitsproducten, verticale coördinatie zoals het gebruik van contracten,…) ook plaatsvinden in lokale ketens.

Tenslotte is er binnen de huidige literatuur ruimte voor onderzoek naar de effecten van horizontale coördinatieprocessen binnen voedselketens, zoals de oprichting van professionele landbouwcoöperatieven. Voor de studies die gepresenteerd worden in hoofdstuk 4 en 5 gebruiken we data die we in 2012 verzamelden bij een 400’tal rurale gezinnen in Rwanda. Aan de hand van deze data analyseren we de impact van lidmaatschap van een landbouwcoöperatieve op de intensivering van de familiale landbouw, de marktgerichtheid, de omzet en inkomsten uit de landbouw. Het landbouwbeleid in Rwanda is erop gericht om binnen de agrarische sector de kleinschalige, familiale landbouw te intensifiëren en een hogere marktgerichtheid te geven. Coöperatieven krijgen hierbij een belangrijke rol toegedicht als katalysatoren om de vooropgestelde doelen te bereiken. Het is echter weinig bekend of deze coöperatieven effectief de vooropgestelde doelen bereiken. In tegenstelling tot de meeste impactstudies -die slechts één enkele coöperatieve of coöperatieven binnen slechts één subsector in rekening brengen- hebben wij uitdrukkelijk aandacht voor de diversiteit in coöperatieven. De structuur en het management van de coöperatieve helpt ons om de heterogeniteit aan effecten die we voor verschillende coöperatieven vinden uit te leggen. Voor deze studie passen we verschillende econometrische technieken toe en houden we rekening met een mogelijke selectiebias. We combineren een “*propensity score matching*” methode, waarbij families vergeleken worden naargelang de waarschijnlijkheid dat ze in een coöperatieve zitten, met een “*proxy variabele*” methode, waarbij we rekening houden met niet-observeerbare persoonlijkheidskenmerken aan de hand van een “*willingness to pay*”

variabele. Onze uiteindelijke resultaten tonen aan dat lidmaatschap van een coöperatieve een positieve impact heeft op verschillende indicatoren. Bijvoorbeeld, lidmaatschap van een coöperatieve verhoogt het aandeel van vermarkte producten met 10 tot 16% punten, verhoogt de besteding aan landbouwmiddelen met 6,000 tot 8,600 RWF, en verhoogt de waarschijnlijkheid dat verbeterde zaden, kunstmest, pesticiden en irrigatietoepassingen worden gebruikt met ongeveer 21 tot 31% punten. We zien ook dat lidmaatschap van een coöperatieve de bruto landbouwinkomsten verhoogt met 37% en het netto landbouwinkomen met 25%, maar deze effecten worden quasi uitsluitend gevonden voor de coöperatieven waarin de individuele verloning naar opbrengst het minst wordt verstoord.

In hoofdstuk 5 analyseren we zowel de exclusiviteit als de effectiviteit van de landbouwcoöperatieven in Rwanda. Door middel van de "*propensity score matching*" technieken schatten we de gemiddelde inkomens- en armoedereductie- effecten die kunnen worden toegeschreven aan het lidmaatschap van een coöperatieve. Anders dan in de meeste impactstudies kijken we verder dan de gemiddelde effecten en evalueren we de heterogeniteit binnen de effecten, m.a.w. het feit dat de effecten niet voor alle gezinnen hetzelfde zijn. We analyseren hoe de effecten van lidmaatschap in een coöperatieve variëren met verschillende kenmerken van de leden, hun familiaal landbouwsysteem, en de geschatte "*propensity score*". We vinden dat voor de leden van een coöperatieve het landbouwinkomen met ongeveer 40 tot 45% stijgt, het totale inkomen met ongeveer 20 tot 25% stijgt en de kans arm te zijn met 10 tot 14% punten daalt. Belangrijk is dat deze effecten het grootst blijken te zijn voor leden met meer landbouwgrond en voor leden in meer afgelegen gebieden. We treffen ook bewijs aan van een negatieve selectie; de grootste effecten worden gevonden voor gezinnen die tegelijkertijd de laagste kans hebben om lid te zijn van een coöperatieve.

List of abbreviations and acronyms

ADEQ	adult equivalents
ANSD	Agence National de la Statistique et de la Démographie
BTC	Belgian Technical Cooperation
CAADP	Comprehensive Africa Agriculture Development Program
CIP	Crop Intensification Program
EICV	Enquête Intégrale sur les Conditions de Vie des ménages or Integrated Household Living Conditions Survey
FDI	foreign direct investment
GAP	good agricultural practices
GDP	gross domestic product
GoR	government of Rwanda
HH	household
hh	household
MINAGRI	Ministry of Agriculture and Animal Resources
NISR	National Institute of Statistics of Rwanda
NUR	National University of Rwanda
PS	propensity score
PSM	propensity score matching
RBS	Rwandan Bureau of Standards
RCA	Rwanda Cooperative Agency
RHIO	Rwandan Horticulture Interprofessional Organisation
RHODA	Rwandan Horticulture Development Authority
RWF	Rwandan Franc
SSA	Sub-Saharan Africa
TLU	tropical livestock units
USAID	US Agency for International Development
WTP	willingness to pay

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Chapter 1
General introduction

1. Food value chains in developing countries

Food value chains involve "*all activities necessary to bring agricultural produce to consumers, including the agricultural production, processing, storage, marketing, distribution, and consumption*" (Gómez et al., 2011 p.1154). In developing countries changes in food value chains emerge due to several factors (Swinnen and Maertens, 2007) such as population and income growth, urbanization and the global and domestic expansions of modern food processing and retail (Reardon et al., 2003; 2009; Reardon and Timmer, 2007). During the last decades domestic markets for high-value products are the fastest growing agricultural markets. For example fruit and vegetable consumption increased with about 160 percent and meat consumption with about 200 percent in the period 1980-2005, while consumption of cereals did not alter (World Bank, 2008). A similar shift, away from staple foods, such as cereals, and traditional tropical exports, such as coffee and cocoa, has been observed in the export sectors (Maertens et al., 2012). Spurred by this increased demand for fresh produce and high-value food products in international and domestic urban markets (World Bank, 2008) developing countries started to deal with modern food value chains through export (Dolan and Humphrey, 2000) and, within countries, through the emergence of modern retail and supermarkets (Reardon et al., 2003; 2009; Reardon and Timmer, 2007).

To enable and facilitate the supply to these dynamic, high-value markets, modernization of food value chains involves institutional innovations such as contract-farming and interlinked market transactions, i.e. increasing levels of vertical coordination in the chain (Swinnen and Maertens, 2007). The emergence of so-called modern food value chains is characterized by particular changes and processes: consolidation and increased dominance of multinational food companies, specialization and differentiation of products, production and marketing. More product-specific characteristics beyond price are required which results in the spread of public and private standards with regard to food quality and safety, environmental impacts, labor conditions, etc. (Gómez et al., 2011; Henson and Reardon, 2005; Maertens and Swinnen, 2009a; 2009b; Reardon et al., 1999; 2009; Reardon and Barrett, 2000; Reardon and Berdegué, 2002; Swinnen, 2007).

Despite the fact that these high-value food chains are emerging in export and retail markets, most of the households in developing countries depend primarily on traditional food value chains for food provision, as outlet for their agricultural production, and as source of employment (Gómez and Ricketts, 2013; Guarín, 2013; Lenné and Ward, 2011). For example, at global level, food exports only account for 1.9% of the volume and 8.4% of the value of domestic production. Further, in-country retail sales of domestically produced foods are 3 to 4 times the sales of food exports (Gómez et al., 2011). Lenné and Ward (2011) put the example of Kenya upfront where, notwithstanding its success in high-value horticulture exports, the domestic markets still account for 90% of the volume and is worth 7 to 8 times the value of the export sector. In the domestic market in developing countries, despite the expansion of modern supermarkets, fresh fruits and vegetables are still primarily accessed through traditional food value chains (Gómez and Ricketts, 2013).

In contrast to modern food value chains, the traditional food value chains are characterized by lower prices for high-value foods (Schipmann and Qaim, 2010), low income consumers (Lippe et al., 2010; Mergenthaler et al., 2009), less diversification and value adding activities in terms of processing, sorting, packaging, etc. (Goldman et al., 2002), few food safety and product quality requirements, little use of public or private standards, less consolidation both at retail and production stage, overall low levels of vertical demand and supply coordination, and more small retailers and producers (Lee et al., 2010) with producers more often organized horizontally in producer cooperatives.

2. Institutional innovations in food value chains

The increased dominance of multinational food companies and the spread of standards have led to important institutional changes in the procurement system in food value chains (Maertens et al., 2012; Swinnen and Maertens, 2007) and a shift from spot market relations to intensified levels of vertical coordination has been observed (Reardon et al., 2009; Swinnen, 2007; Swinnen and Maertens, 2007). Vertical coordination entails a continuum of institutional arrangements from spot market transactions to full vertical integration with intermediate forms of coordination such as contracting and interlinked markets (Hobbs and Young, 2000).

In a contract-farming scheme local households are mainly affected through product markets and formal and informal product and marketing contracts are put in place. Where before it was mainly seen as a government's responsibility to provide (access to) credit or

inputs, in modernizing chains private sector actors become involved in the provision of these services and interlinked markets re-emerge (Reardon et al., 2009; Reardon and Berdegué, 2002; Swinnen and Maertens, 2007).

Several studies have documented a chain restructuring from intermediate forms of vertical coordination, such as the contract farming schemes, towards systems of (almost) full vertical integration. For example, Minot and Ngigi (2004) documented a shift towards vertically integrated estate production in the pineapple sector in Kenya and in the banana sector in Ivory Coast. Dolan and Humphrey (2000) observed that the share of smallholders in the fresh vegetable export trade in Kenya and Zimbabwe is decreasing and that there is a tendency towards vertical integration in the chain (Dolan and Humphrey, 2000). In the vegetable export sector in Senegal a recent shift, induced by the increased importance of standards, took place from smallholder contract-based farming to vertically integrated production on large plantations (Maertens et al., 2012; Maertens and Swinnen, 2009a). Schuster and Maertens (2013) found that in the asparagus export sector in Peru export companies reduced the share of produce sourced from smallholder farmers due to the use of private standards. The shift towards full vertical integration did not only create additional employment on the fields of the export companies. The increased importance of standards increased the need for labor in post-harvest activities such as sorting, grading, washing, labeling etc. Thus vertically integrated food value chains can result in important labor market effects through employment opportunities[1] for rural households (Maertens et al., 2012).

Analyzing institutional innovations in modern value chains does not only entail considering vertical coordination processes, horizontal linkages do play an important role as well (Kaplinsky and Morris, 2001). At the level of rural producers, horizontal coordination -in the form of cooperative producer groups, for example- is seen as a vital way to enable smallholders to engage and benefit from modernizing and new food value chains (Coles and Mitchell, 2011; Markelova et al., 2009; Markelova and Mwangi, 2010; World Bank, 2008). However, whether these institutions are inclusive, effective and/or sustainable, depends on many features, for example the type of products and markets, group and member characteristics, … (Coles and Mitchell, 2011; Markelova et al., 2009). However, recent literature on food value chain innovations and its development implications mostly focuses on

[1] For example, employment on the fields of large-scale companies, post-harvest handling and processing such as sorting, grading, washing, packaging, labeling, …

vertical coordination processes such as contract farming in global export and supermarket chains.

Although modern food value chains are often studied as separate systems, in developing countries today, food value chains exhibit great diversity and modern food value chains exist in conjunction with the traditional chains (Gómez and Ricketts, 2013). There is considerable overlap between traditional and modern food value chains resulting in more complex and sophisticated networks (Guarín, 2013). For example, product innovations in developing countries are often introduced through modern supply chains but positive spillovers to traditional markets do occur (Schipmann and Qaim, 2010). In their study on sweet pepper in Thailand, Schipmann and Qaim (2010) document a spillover effect from product innovation processes in the modern supply chains to the more traditional markets. The newly introduced sweet pepper contributed significantly to higher incomes both for farmers supplying the modern food value chains and for the farmers supplying sweet pepper to traditional wholesale and retail markets. By the size and importance of the domestic market, the potential spillovers from modern value chains might even result in greater economic gains and poverty reduction (Goméz et al., 2011; Lenné and Ward, 2011; Schipmann and Qaim, 2010).

3. Development implications

Although food production and trade in developing countries is highly influenced by the emergence of and the modernization in food value chains, there is no consensus (yet) on the overall welfare implications (Maertens et al., 2012). Different forms of coordination processes occur, for example vertical integration, contract farming, horizontal coordination towards producer cooperatives. To analyze the overall development implications of these institutional processes for rural households a distinction can be made between the analysis of inclusiveness and effectiveness (Table 1). Studying the inclusiveness relates to whether (and which type of) rural households are included in or excluded from participation in the value chain. Effectiveness relates to the impact of participation and can be further differentiated in the direct effects of participation in the value chain -i.e. the impact on agricultural productivity, product quality, farm and total household incomes- and indirect effects that emerge through spillover effects (Maertens et al., 2012; Swinnen and Maertens, 2007).

Table 1. Different types of effects for vertical integration, contract farming schemes and horizontal coordination towards producer cooperatives

	Vertical Integration	Contract farming schemes	Horizontal coordination towards producer cooperatives
Inclusiveness	Exclusion/inclusion of rural households from employment opportunities	Exclusion/inclusion of smallholder farmers to supply through contract farming	Exclusion/inclusion of rural households from membership of producer cooperatives
	Type of households with access to employment, type of people employed	Type of households with access to or selected for contract farming schemes	Type of households with access to membership, characteristics of cooperative members
Effectiveness			
- Direct effects	Impact of employment on household income and poverty reduction	Impact of smallholder participation in contract farming schemes on productivity, household income and poverty reduction	Impact of participation in producer cooperatives on productivity, household income and poverty reduction
- Indirect effects	Spillover effects from employment, e.g. investment and consumption linkages, health and overall well-being	Spillover effects from smallholder participation in contract farming schemes, e.g. technology and managerial spillovers, investment and consumption linkages, health and overall well-being	Spillover effects from membership in producer cooperatives, e.g. technology and managerial spillovers, investment and consumption linkages, health and overall well-being

(Source: adapted from Maertens et al., 2012)

Inclusiveness and effectiveness of contract farming

Analyzing the inclusiveness of contract farming schemes, studies have shown mixed evidence on the exclusion of smallholders from (or inclusion in) modern food value chains. For example, research on the horticultural sector shows that smallholder producers are often excluded from modern retail and export chains (Reardon and Berdegué, 2002)[2]. Other studies, however, have shown that smallholders can be included in modern chains. For example, Minten et al. (2009) found small farmers in Madagascar to be largely included in the export vegetable chain through contracting. Key and Runsten (1999) reported successful contracting between agro-processing companies and smallholders in Mexico. Further, in the green beans sector in Senegal and the fruit and vegetable sector in Kenya smallholders are involved in contracting schemes with exporters (Jaffee, 2003; Maertens and Swinnen, 2009a). Case studies in Bangladesh, India, Pakistan, Indonesia, the Philippines, Thailand, Vietnam, and China reveal an overwhelming predominance of smallholders included in vertically coordinated food retail and agro-processing chains through the use of contracting (Gulati et al., 2007). Wang et al. (2009) documented that poor smallholder farmers are actively involved in China's growing horticultural sector.

[2] See case studies in Argentina (Ghezán et al., 2002) in Brazil, Costa Rica, Guatemala, and Nicaragua (Balsevich et al., 2003), in Chile (Handschuch et al., 2013), and in Russia (Dries et al., 2007).

Other studies differentiated among smallholders and indentified which types of households are more likely to have access to contract farming schemes. Based on farm, household and individual characteristics of a rural producer, most studies found participation to be more likely for those households with higher endowments in financial, human, social and natural capital. Michelson (2013) observes that for vegetable farmers in Nicaragua, location and natural resource endowments are important determinants of participation in a supermarket supply chain. Neven et al. (2009) and Rao et al. (2012) point out that supermarkets in Kenya are mainly supplied by an emerging middle-class of horticulture farmers who have a higher degree of education, more farming experience, more land and access to transport. Similar findings are documented in other cases; for example in horticulture chains in Thailand (Kersting and Wollni, 2012), Madagascar (Bellemare, 2012), Ghana (Legge et al., 2006), Kenya (McCulloch and Ota, 2002), and Ivory Coast (Minot and Ngigi, 2004).

With regard to the direct effects of participation, empirical studies mostly show evidence of positive effects. For example Minten et al. (2009) and Bellemare (2012) find positive effects on income and income stability for smallholder producers involved in vegetable contract farming in export supply chains in Madagascar. Rao et al. (2012) show that participation of vegetable growers in supermarket channels in Kenya increases farm productivity and improves technical efficiency and scale efficiency. Michelson (2013) demonstrates that in Nicaragua participation in supermarket supply chains increases farmer households' productive assets equivalent to an increase in households' income with about 15%. Vandeplas et al. (2012) find that farmers supplying the multinational dairy channel in India are more efficient in terms of productivity and profitability levels. McCulloch and Ota (2002) show in Kenya that farmers who are involved in contract farming schemes for horticulture export chains derive higher incomes.

Empirical evidence with regard to potential indirect effects is more scarce. Smallholder participation in the Madagascar vegetable export chain has resulted in an improved adoption of composting, which has potential spillover effects on overall soil fertility, and improved productivity of the staple crop rice. Participating households also indicated to have shorter lean periods (Minten et al. 2009). Asfaw et al. (2010) find evidence of nonfinancial benefits for smallholders through contracting with certified horticulture exporters in Kenya. These farmers are more aware of good agrochemical practices and are experiencing improved hygiene conditions on the farm which in turn can have beneficial effects on food safety, farmers' health, and the environment. In Senegal, Dedehouanou et al. (2013) observe that

contract farming in the tomato export sector contributes to subjective well-being. There may also be positive indirect effects to traditional labor markets. For example, Rao and Qaim (2013) and Neven et al. (2009) demonstrate that participation in the Kenyan supermarket chain increases informal agricultural wage employment for non-participants (Neven et al., 2009; Rao and Qaim, 2013).

Inclusiveness and effectiveness of vertical integration

Recently, several authors indicate that, through increased vertical integration, supply chains can have important direct and indirect labor market effects. More specifically, empirical evidence shows that employment in these agricultural and agro-industrial chains is not biased towards better-endowed and/or better educated households but is accessible for women from poor households (Barron and Rello, 2000; Colen et al., 2012; Maertens, 2009; Maertens and Swinnen, 2009a; Rao and Qaim, 2013).

Direct income gains from employment in the horticulture export chain are documented by Barron and Rello (2000), Maertens (2009), Maertens and Swinnen (2009a), Maertens et al. (2011), and McCulloh and Otta (2002). In some cases employment opportunities on large farms or in exporting companies offset the loss of income from smallholder production (Humphrey et al., 2004; Maertens and Swinnen, 2009a). Colen et al. (2012) complement these findings with evidence that employment in certified fruit and vegetable export chain is associated with even higher wages and longer employment periods.

Despite the global trend of increased vertical integration leading to additional employment opportunities for poor households, few studies have looked beyond direct effects. Indirect effects from off-farm employment in modern food value chains is documented by Maertens (2009) and McCulloh and Otta (2002). Maertens (2009) finds evidence of the existence of farm - non-farm investment linkages in poor rural households where the off-farm income is partially invested in the family farm. McCulloh and Otta (2002) record a substantial reduction in households' food poverty if a household member is employed in the horticulture export chain.

Inclusiveness and effectiveness of horizontal coordination

Various empirical studies investigated which farmers are included in (or excluded from) cooperatives and producer organizations. The prevailing evidence suggests that these forms of horizontal coordination are exclusive to some extent. In general, participation is found to be

closely linked to human and social capital (Hellin et al., 2009), access to social networks and information (e.g. Fischer and Qaim, 2012; Markelova and Mwangi, 2010; Matuschke and Qaim, 2009; Okello et al., 2007), physical capital and farmers' asset endowments (e.g. Bernard and Spielman, 2009; Fischer and Qaim, 2012; Ito et al., 2012). Some studies conclude that the poorest are excluded (e.g. Fischer and Qaim, 2012; Francesconi and Heerinck, 2010; Ito et al., 2012; Quisumbing et al., 2008) while others point to a middle-class effect with both the poorest and the most wealthy farmers least likely to participate (Bernard and Spielman, 2009).

Concerning the direct effects of participation in producer cooperatives, several recent studies report positive product market effects of cooperative membership on specific aspects of smallholder farm performance. For example, cooperative membership is found to positively affect producer prices, to improve market access and participation (e.g. Abebaw and Haile, 2013; Bernard et al., 2008; Bernard and Taffesse, 2012; Fisher and Qaim, 2012; Francesconi and Heerink, 2010; Holloway et al., 2000; Ito et al., 2012; Shiferaw et al., 2009; Wollni and Zeller, 2007) and to increase the likelihood of adopting improved technologies (e.g. Abebaw and Haile, 2013; Francesconi and Heerink, 2010; Shiferaw et al., 2009). Other studies point to a positive impact of cooperative membership on farm incomes and profits (e.g. Fisher and Qaim, 2012; Ito et al., 2012; Vandeplas et al., 2013). Yet, the indirect effects have rarely been analyzed and few studies explicitly look at differences in impact across different cooperatives and across cooperative members.

4. Focus and research gaps addressed

In this dissertation, we focus on three main research gaps that need to be addressed if one wants to have a better understanding of the multiple dimensions of food value chains, their performance and their development implications.

First, concerning the export food value chains, empirical studies mostly focused on the inclusiveness of vertical coordination schemes and the direct and indirect product market effects, especially with regard to contract farming. However, as there is a global trend of increased vertical integration leading to additional employment opportunities for poor households, labor market effects become more important. Few studies have looked at the indirect effects of increased rural employment in export value chains. In chapter 2, we address

the indirect effect of the boom in horticultural exports and rural employment in this export value chain in Senegal on child schooling.

Main hypothesis chapter 2: Female wage employment in horticultural export companies in Senegal has a positive effect on primary school enrolment.

Second, the existing literature mostly focuses on higher-value supply chains involving export markets or domestic supermarkets. However, as there is considerable overlap between so called 'modern' and 'traditional' food value chains, the landscape of food value chains is more diverse. New studies should take into account that a wide variety of food value chains exist in a country and differentiate beyond the current dichotomy of modern versus traditional. In chapter 3, we conduct a value chain analysis of horticulture value chains in Rwanda, taking into account that processes of modernization -as spillover effects from the innovation processes in the modern chains- also take place in the domestic and local horticultural chains.

Main hypothesis chapter 3: Supply chains can be differentiated beyond the dichotomy of 'traditional' versus 'modern' chains.

Third, recent literature on food value chain innovations and its development implications mostly focuses on vertical coordination processes and more research is needed on horizontal coordination at producer level. In chapter 4, we study the impact of participation in agricultural producer cooperatives on agricultural performance in Rwanda. We make use of the diversity with respect to cooperative structure, organizational differences and crop types to study the heterogeneity in effects of membership in different types of cooperatives. In chapter 5, the Rwandan case study is used to analyze both the inclusiveness and effectiveness of cooperative membership and to evaluate the impact heterogeneity on households' income and poverty across farmers.

Main hypothesis chapter 4: Cooperative membership has a positive impact on farm performance.

Main hypothesis chapter 5: The effect of cooperative membership on households' income and poverty is heterogeneous across farmers.

5. Case study I: Vertical integration in the horticulture export sector in Senegal

Over the past 10 years, Senegalese horticultural exports to the European Union increased sharply. The export boom and the increasing importance of public and private standards, in which foreign direct investment played a major role, resulted in a structural reorganization in the export supply chain. There are two main horticulture zones in Senegal: "*Les Niayes*" along the North Coast of Dakar for the export of beans and mangoes and the "*Senegal River Delta*" close to the Mauritanian border for the export of tomatoes. There are substantial differences between the export supply chains for tomatoes and the bean and mango export supply chains (Maertens and Swinnen, 2012). For the tomato export sector in Senegal, the chain is completely vertically integrated and characterized by the use of standards and consolidation. Thus, smallholder farmers are not included in this chain as suppliers but they can be included in the chain as employees because labor-intensive activities like harvesting, packing and labeling is done manually (Maertens et al., 2011). In the region of "*Les Niayes*" smallholder contract farming coexists with vertically integrated agro-industrial production. However, the introduction of GlobalGap standards, mainly in the bean sector, is causing a profound shift in the supply chain towards full-ownership integrated production with decreasing shares of produce procured from smallholders (Maertens and Swinnen, 2009a; Maertens and Swinnen, 2012). Thus, rural households in the "*Senegal River Delta*" are mainly affected through the labor market created by the tomato exports while the shift towards complete vertical integration in "*Les Niayes*" resulted in the fact that rural households in the bean and mango export are increasingly affected through labor markets instead of through product markets (Maertens and Swinnen, 2012).

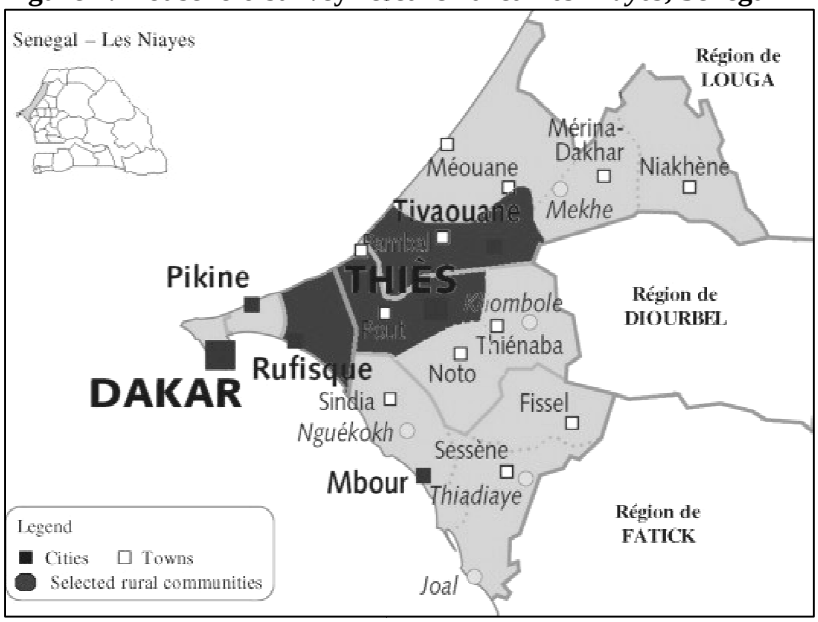
The research of Maertens et al. (2011) reveals that the labor market in the tomato export sector in the "*Senegal River Delta*" has a significant positive impact on households' income and that the income gains from employment offset the possible income losses in the product market. Further, inclusion in this labor market is not biased towards relatively better-off or better educated households.

Maertens and Swinnen (2009a) document for the region of "*Les Niayes*" that participation in the export chain, whether through contract farming or through agro-industrial employment, significantly increases rural incomes and has a poverty reducing effect. While contract farming is biased toward better-off households with larger landholdings, the employment in

the vertically integrated agro-industry is not (Maertens and Swinnen, 2009a). There are also positive spillover effects from the employment in this horticulture export industry on households' family farm production, as earnings from the employment are partially invested in the households' agricultural production by increasing landholdings and input expenditures (Maertens, 2009). The employment opportunities are especially important for women, as they do benefit more and more directly through the labor market effects than through product market effects from contract-farming (Maertens and Swinnen, 2012). Further, Colen et al. (2012) find evidence that the use of GlobalGap certification in these industries is associated with important benefits for the employees as wages increase and employment periods expand.

The data used in chapter 2 stem from a household survey implemented by researchers Maertens M., Colen L., Vandemoortele T., and Dedehouanou S. in 2007 in the *Niayes* region, where some 20 export companies are located (see Figure 1).

Figure 1: Household survey research area *Les Niayes*, Senegal



(Source: Map from Atlas du Sénégal−IRD−Cartographie A. LE FUR−AFDEC)

Previous studies have shown important labor and product market effects associated with the horticulture export sector in Senegal, but potentially important indirect effects remain unexplored. The allocation of female labor towards off-farm employment might alter the allocation of household resources and/or might interfere with women's reproductive work. For example, one might expect female income to be positively correlated with spending on children's education. However, increasing female employment in the agro-industry can also have adverse effects on the schooling of children if, for example, children are withdrawn from school either to participate in the labor market or to substitute for their mothers' household

and child care activities. In chapter 2 we address a completely unexplored issue and analyze the indirect effects of the boom in horticultural exports in Senegal on child schooling.

6. Case study II: Horizontal coordination in food value chains in Rwanda

The agriculture policies and strategies in Rwanda combine a focus on food security and economic development. For the Government of Rwanda, a modernization and professionalization of the agricultural sector is seen as a vital pathway for economic development, poverty reduction and food security. To achieve these goals the government promotes the development of modern food value chains to intensify agricultural production and increase market orientation of the smallholder sector (GoR, 1999; 2001; 2004; 2007; 2008). To increase private sector development within production, processing, and marketing of agricultural products a significant share of the budget is allocated to creating an attractive investment climate (GoR, 2004). For example, in the second strategic plan for the transformation of the agricultural sector (2008) 12% of the budget is assigned to the promotion of commodity chains and agribusiness developments, for example by stimulating the production of high-value horticulture products, by expanding non-traditional exports, by creating improved rural infrastructure to increase the market orientation, etc. Taking the budget for promotion of farmers' organizations and capacity building for producers (1.3%) and the budget for research (7%) into account, in total 20% of the budget is allocated to the development of modern food value chains (GoR, 2008).

Taking the horticultural export booms in Kenya, Senegal, South Africa and Ethiopia as an example, special efforts are made to attain the high economic potential of horticulture export crops. Unlike the horticulture supply chains in the above-mentioned countries, the development of a high-value horticulture value chain is still at its infancy in Rwanda. In chapter 3, we use the value chain concept and analyze the development of the horticultural sector and the emerging horticultural value chains in Rwanda. We identify different stages within the chain and, within each stage, we describe different aspects of the actors (e.g. type of farmers, type of buyers, degree of consolidation, length of the chain), the activities (e.g. post-harvest value-adding, quality differentiation) and the transactions and the coordination (e.g. degree of vertical coordination, type of contracts, use of certificates and labels) between actors in the chain. In this analysis, we take into account that a wide variety of food value

chains can exist in conjunction with each other and that processes of modernization are also to be expected in domestic chains.

Another distinct feature of the value chain developments in the agricultural sector in Rwanda is the high intensity of government intervention and the important role for farmer cooperatives. The horizontal coordination of smallholders in producer cooperatives is observed in different agricultural subsectors, for example the coffee en tea sector, the maize and the horticultural sector. Cooperatives are expected to act as economically productive enterprise and as vehicles through which members can "*create employment, …expand access to income-generating activities, develop their business potential, …entrepreneurial and managerial capacities…, increase savings and investment, and improve social well-being…*" (RCA, 2011). There are however few studies that analyze the inclusiveness and effectiveness of this type of horizontal coordination. In chapter 4 and 5, we study the inclusiveness and effectiveness of participation in agricultural producer cooperatives Rwanda. We analyze the heterogeneity in effects on farm performance in different types of cooperatives in chapter 4. In chapter 5, we evaluate the impact heterogeneity on households' income and poverty across farmers.

For the case study in Rwanda in total three field visits have been executed. A first explorative field visit was carried out between July and September 2010 in cooperation with the National University of Rwanda (NUR) and RHODA (Rwandan Horticulture Development Authority), a department at the Ministry of Agriculture and Animal Resources (MINAGRI). During the second visit from February to April 2011 data from secondary sources and stakeholder interviews in the main horticultural regions were collected in cooperation with RHODA. In total about 80 structured interviews with actors at different levels of the horticultural supply chains were collected to provide data for the value chain analysis of the horticultural sector as presented in chapter 3. During the third visit from February to March 2012, about 400 household level surveys were collected in Muhanga, an administrative district in the Southern province of Rwanda (Figure 2). These household survey data are used for the analyses in chapter 4 and 5.

The Muhanga district is located on the road between the country's capital city Kigali and the southern and western provinces; the road that also connects the capital with the Republic of Burundi and Eastern part of Democratic Republic of Congo. This strategic location makes the district thus not only important for the supply of food, especially vegetables, fruit and

meat, to Kigali, at the same time it serves as a transit point for the trade of food, services and other businesses between the capital and the southern part of the country. In the district, the majority of the population is working as an independent farmer (74%) with half of the households' income derived from agriculture (55%)[3] (NISR, 2013).

Figure 2: Research area in the Muhanga District of Rwanda

(Source: Adapted from CGIS-NUR, 2009)

[3] Other sources of income like wage income, rents, business income and private transfers contribute, respectively, 20%, 9%, 8% and 7% to a household's income. The national average of the share of the population being independent farmers is 62% and on average 46% of the household's income is derived from agriculture.

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Chapter 2

Horticultural exports, female wage employment and primary school enrolment: Theory and evidence from Senegal*

1. Introduction

The recent horticultural export boom in developing countries is a much debated issue. It is recognized that horticultural exports entail the potential to raise rural incomes and alleviate poverty because of the high intrinsic value of produce and the labour-intensive production systems (Maertens et al., 2012). There is a growing body of empirical literature that analyses the welfare effects of horticultural exports (Mithoefer and Waibel, 2011). Most studies point to positive effects through product markets. Smallholder contract farming with horticultural export companies has been found to positively affect farm productivity, rural incomes, poverty reduction and farmer wellbeing (Asfaw et al., 2010; Dedehouanou et al., 2013; Maertens and Swinnen, 2009; Minten et al., 2009). Some studies emphasize the exclusion of poorer farmers and women from contracting in horticultural export chains (e.g. Dolan, 2001; Dolan and Humphrey, 2000; McCulloch and Ota, 2002; Singh, 2003). A few studies emphasize that important effects emerge through labour markets as well and showe that horticultural exports importantly contribute to poverty reduction through the creation of rural employment (e.g. Barron and Rello, 2000; Colen et al., 2012; Maertens and Swinnen, 2009; Maertens et al, 2011).

Yet, few studies have looked beyond direct income and poverty effects. Exceptions include Minten et al. (2007) who find that smallholder contract farming with horticultural export companies in Madagascar leads to increased rice yields through technology spillover effects. Asfaw et al. (2009) find that there are managerial spillover effects from contracting with certified horticultural exporters in Kenya, leading to less hazardous pesticide use and improved health conditions of farmers. Maertens (2009) finds that wage employment in the

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horticultural export industries in Senegal creates investment pullovers and leads to higher input use and improved productivity in smallholder production for the local market.

In this paper we address a completely unexplored issue and analyse the indirect effects of the boom in horticultural exports in Senegal on child schooling. Previous studies show that this export boom is associated with a sharp increase in rural employment, especially female employment, and that this employment importantly contributes to poverty reduction and female empowerment[1] (Maertens and Swinnen, 2009, 2012; Maertens et al., 2011). In this paper we analyse whether female wage employment in the horticultural export sector and associated female empowerment results in better outcomes for children, with a focus on primary school enrolment of boys and girls.

This is an important question because education is a critical asset for rural people and an important determinant of agricultural growth and rural development in the long run (World Bank, 2008). As with many other assets, nowhere is the lack of education as large is in Sub-Saharan Africa (SSA). Adult literacy is only 62% in SSA – compared to more than 90% in East Asia and Latin America (World Bank, 2010). More anxiously, progress in education is slow. Primary school enrolment is only 76% in SSA while close to 100% in East Asia and Latin America (World Bank, 2010). Currently still 69 million of primary school-age children are not in school worldwide, about half of them in SSA (United Nations, 2010). In Senegal, primary school enrolment is even below the SSA average with huge disparities between rural and urban areas and between boys and girls (Bennell, 2002). Primary school enrolment is estimated at 78% for boys and 73% for girls in urban areas versus 62% for boys and 51% for girls in rural areas (Montgomery and Hewett, 2005).

In 2001 Senegal adopted a change in the constitution that stipulates the responsibility of the state to provide adequate public institutions to guarantee primary education for all children, and that all children, boys and girls, have the right to go to school (République du Sénégal, 2003). After this, in 2003, the government of Senegal embarked on a '*Primary education for all – Education première pour tous'* program under the auspices of the United Nations and with the support of several donors such as the World Bank, USAID and the French Development Agency. The program has mainly focussed on the supply side of schooling; on increasing the number and the quality of classrooms, the quality of teachers,

[1] Other studies however point towards existing gender discrimination in wages and employment conditions in horticultural export sectors (e.g. Barrientos and Kritzinger, 2004; Barrientos et al., 2003).

and the availability of textbooks. As a result, net primary school enrolment in Senegal increased from 62% in 2003, when the program started, to 73% in 2009 (World Bank, 2010). This progress is important but not sufficient to guarantee primary education for all by 2015.

Education programs that focus on the supply side of schooling are necessary but they do not suffice to reach the second Millennium Development Goal of universal primary school enrolment. A low demand for primary education among poor and rural households has been argued to be the most critical factor in low primary school enrolment rates in SSA (Bennell, 2002). Empirical evidence from several developing countries has shown that household income and wealth are the main factors determining schooling (e.g. Behrman and Knowles, 1999; Gitter and Barham, 2008; Lincove, 2009; Rosati and Rossi, 2003; Tansel, 1997; Zhao and Glewwe, 2010). Also the sources of household income and parental occupation matter, with evidence pointing to children from self-employed parents being less likely to be in school than children from employees (e.g. Grootaert and Kanbur, 1995; Parikh, 2005). It has been argued that in addition to the level of income, intra-household control over income and resources matters for school enrolment. Some studies empirically document that increased bargaining power for women increases school enrolment or school expenditures (or decreases child labour) (e.g. Gitter and Barham, 2008; Lancaster et al., 2006; Reggio, 2011; Thomas, 1994). Our study will contribute to this literature by focussing on female off-farm wage income and its effect on child school enrolment.

To analyze the effect of female wage employment in the export agro-industry on primary school enrolment, we first develop an analytical framework based on a household bargaining model in which the bargaining power of women is a function of their off-farm wage income. Our model is inspired by Basu (2006), Emerson and Souza (2007), and Reggio (2011), but focuses more generally on the impact of maternal wage income on child school enrolment and also accounts for effects that are not necessarily related to the distribution of power in the household. The theoretical analysis reveals that the impact of maternal wage income on child schooling results from three different effects: an income effect, a labour substitution effect, and an empowerment effect. The ultimate effect remains an empirical question, which we address using original and unique household survey data from the *Niayes* region, the main horticultural region in Senegal. The horticultural export boom has caused a tremendous and sudden increase in female off-farm wage employment on the fields of large agro-industrial estates and in processing and packing units since the early years 2000. This is an ideal case to test whether the horticultural export boom and associated female wage employment has

caused indirect effects on child schooling. We use different econometric techniques to estimate the casual effect of female wage income on the propensity of children to be in school, controlling for individual, household and village characteristics. We find that female wage employment in the horticultural export industry has a significant positive and large effect on primary school enrolment for both boys and girls, and that female empowerment is specifically important for the schooling of girls.

2. A collective household model

To derive how female wage employment affects child school enrolment, we consider a collective household bargaining model[2]. The collective model is a non-unitary cooperative household model in which it is assumed that bargaining between household members leads to Pareto efficient outcomes. While the use of non-unitary household models is widely supported (e.g. Haddad et al., 1997; Kevane, 2011), there is no unequivocal support for either cooperative or non-cooperative models. The use of cooperative models is rejected by some empirical studies (e.g. Ashraf, 2009; Doss and Mc Peak, 2006; Udry, 1996) but supported by others (e.g. Bobonis, 2009; Browning and Chiappori, 1998). Our approach follows the evidence provided by e.g. Dauphin et al. (2006), Goldstein and Udry (2008), and Rangel and Thomas (2005), who do not reject efficient bargaining in West-African households.

We consider a household consisting of a female and male head and an unspecified number of children. The household's utility (U) is a weighted sum of women's (U_f) and men's (U_m) utility. The weight (θ) captures the relative balance of power in the household; θ increases the relative bargaining power of the wife and men's bargaining power is normalized to one:

$$U = \theta U_f + U_m \tag{1}$$

We assume that utility is a concave function of consumption (C), leisure (l_f and l_m) – with women/men deriving utility only from their own individual leisure time – and the schooling of children (S).

$$U = \theta U_f\left(C, l_f, S\right) + U_m(C, l_m, E, S) \quad \text{with} \quad \begin{matrix} \forall x \in C, l, S\colon U_x > 0,\ U_{xx} < 0 \\ \forall x \in C, l, S;\ \forall y \in C, l, S\colon U_{xy} < 0 \end{matrix} \tag{2}$$

[2] The model is inspired by Basu (2006), Emerson and Souza (2002; 2007), and Reggio (2011).

We assume no savings and investment in the model such that income is completely consumed – this is not a crucial assumption while it simplifies the model. Income is derived from own household production – this includes production at the household farm but can include off-farm businesses and households' reproductive and maintenance activities as well – and from wage employment outside the household. Household production is a concave function of labour (L) and land or other fixed assets (A). Both women and men allocate labour to household production (L_f and L_m). Children can either work in the household (L_c), go to school (S), or both. Household production can be sold in the market or can be consumed directly and is valued at a price p. As we are specifically interested in the impact of maternal off-farm wage employment on child education, we assume for the moment that only women can involve in employment outside the household (E) for a wage (w). We assume that men derive disutility when their wives work off-farm in wage employment, such that $\delta U_m/\delta E < 0$. This represents a traditional society where social and cultural norms prohibit women to participate in the labour market.

Schooling of children is assumed to have a direct impact on utility and to entail a direct cost (q), including school fees and other school-related expenses (uniform, books, stationary, etc.).

$$C = pf\left(L_f, L_m, L_c, A\right) + wE - qS \text{ with } \forall x \in L_f, L_m, L_c, A\text{: } f_x > 0, f_{xx} < 0 \quad (3)$$
$$\forall x \in L_f, L_m, L_c, A;\ \forall y \in L_f, L_m, L_c, A\text{: } f_{xy} < 0$$

We assume men and women always spend some time on household production and that female wage employment and child schooling can be zero or positive:

$$L_m, L_f > 0,\ E \geq 0 \text{ and } S \geq 0 \quad (4)$$

We further assume that men's, women's and children's time constraints are always binding:

$$l_f = 1 - L_f - E,\ l_m = 1 - L_m \text{ and } S = 1 - L_c \quad (5)$$

In most collective household models and empirical studies estimating the impact of female bargaining power on child outcomes, the balance of bargaining power between men and women is assumed to be determined by women's income generating capacity, to be exogenous and related to female-specific non-labour income (e.g. Thomas, 1994), the prevailing market wage rate for female workers (e.g. Bourguignon and Chiappori, 1994;

Moehling, 1995) or women's education relative to men's education (Gitter and Barham, 2008). Inspired by Basu (2004), we use a different approach and consider the bargaining power of women in the household to depend on what women actually earn in the labour market (Ew), and on a vector of exogenous factors (z): $\theta(Ew, z)$ with $\theta_E > 0$ and $\theta_{EE} \leq 0$. Hence, bargaining power is endogenous in the model as it is influenced by the decision on female wage employment.

We assume that women's bargaining power depends on off-farm wage income but not on women's return to labour in household (farm) production. This is quite realistic for rural areas in Africa, where family labour is often unpaid and where women's say over farm income is low because they lack statutory rights over land. Off-farm wage employment, on the other hand, might contribute to female empowerment in the household because the income derived from wage employment is more directly attributable to women's own labour and because women directly receive the cash (Maertens and Swinnen, 2012; Zhang et al., 2004).

The collective household decides on female and male labour in household production (L_f and L_m), female labour in off-farm wage employment (E), and the schooling of children (S). The household's maximization problem can be written as:

$$Max\ \theta U_f\big(C, 1 - L_f - E, S\big) + U_m(C, 1 - L_m, E, S) \tag{6}$$
$$\text{with} \quad C = pf\big(L_f, L_m, 1 - S, A\big) + wE - qS$$
$$\text{subject to} \quad E \geq 0 \text{ and } S \geq 0$$

The objective function of the maximization problem is:

$$\Psi = \theta U_f\big(C, 1 - L_f - E, S\big) + U_m(C, 1 - L_m, E, S) - \mu S - \pi E \tag{7}$$

The maximization leads to the following Kuhn-Tucker first order conditions:

$$\frac{\partial \Psi}{\partial L_m} = 0 \ \Rightarrow\ \theta \frac{\partial U_f}{\partial C} pf_{L_m} + \frac{\partial U_m}{\partial C} pf_{L_m} - \frac{\partial U_m}{\partial l_m} = 0 \tag{8}$$

$$\frac{\partial \Psi}{\partial L_f} = 0 \ \Rightarrow\ \theta \frac{\partial U_f}{\partial C} pf_{L_f} + \frac{\partial U_m}{\partial C} pf_{L_f} - \theta \frac{\partial U_f}{\partial l_f} = 0 \tag{9}$$

$$\frac{\partial \Psi}{\partial E} \leq 0;\ E \frac{\partial \Psi}{\partial E} = 0$$
$$\Rightarrow\ \theta_E U_f + \theta \frac{\partial U_f}{\partial C} w - \theta \frac{\partial U_f}{\partial l_f} + \frac{\partial U_m}{\partial C} w + \frac{\partial U_m}{\partial E} - \pi \leq 0 \tag{10}$$

$$\frac{\partial \Psi}{\partial S} \leq 0;\ S\frac{\partial \Psi}{\partial S} = 0$$

$$\Rightarrow\ \theta\frac{\partial U_f}{\partial S} + \frac{\partial U_m}{\partial S} - \theta\frac{\partial U_f}{\partial C}\left(pf_{L_c} + q\right) - \frac{\partial U_m}{\partial C}\left(pf_{L_c} + q\right) - \mu \leq 0 \qquad (11)$$

Rearranging equation (8) and (9) leads to the first two equilibrium conditions (12 and 13), specifying that women and men will allocate labour to household production such that the marginal return to that labour equals their implicit or subjective wage rate. The latter is given by the marginal rate of substitution of own leisure for weighted consumption. In their labour allocation decisions, both men and women take into account the effect on the other person's utility. According to equation (12), women with a higher bargaining power in the household will work less and will have a higher marginal value product of labour in household production.

$$pf_{L_m} = \frac{\frac{\partial U_m}{\partial l_m}}{\theta\frac{\partial U_f}{\partial C} + \frac{\partial U_m}{\partial C}} \qquad (12)$$

$$pf_{L_f} = \frac{\theta\frac{\partial U_f}{\partial l_f}}{\theta\frac{\partial U_f}{\partial C} + \frac{\partial U_m}{\partial C}} \qquad (13)$$

Substituting (13) in equation (10) and rearranging leads to a third equilibrium condition (14), indicating that women will work in off-farm wage employment if the market wage rate reaches a level that is equal to the marginal return to women's labour in household production minus factors T and R, expressing respectively the disutility men derive and the bargaining power women gain when women participate in the labour market:

$$E\begin{cases} = 0 & if\ w < pf_{L_f} - R - T \\ > 0 & if\ w = pf_{L_f} - R - T \end{cases} \quad \text{with} \quad R = \frac{\theta_E U_f}{\theta\frac{\partial U_f}{\partial C} + \frac{\partial U_m}{\partial C}} \qquad (14)$$

$$T = \frac{\partial U_m/\partial E}{\theta\frac{\partial U_f}{\partial C} + \frac{\partial U_m}{\partial C}}$$

Since pf_{L_f} is increasing with θ, women who initially have a smaller bargaining power will have a lower reservation wage because their marginal return to labour in household production is lower. The factor R reduces women's reservation wage because women derive additional utility from working outside the household through increased bargaining power. Since R is decreasing with θ, women with an initial lower bargaining power will have a lower

reservation wage and will be more inclined to enter the labour market. Yet, the factor T increases women's reservation wage (since $\delta U_m/\delta E < 0$, T is negative) because men dislike women to work outside the household. Since T is decreasing with θ, a low bargaining power will increase the reservation wage and reduce women's labour market participation. In traditional societies $\delta U_m/\delta E$ might be quite large and prevent women from entering the labour market. If wages rise – e.g. because of a horticultural export boom and associated demand for wage labour as in our case-study – women with a relatively high bargaining power will enter the labour market. As more women work in wage employment, socio-cultural norms might change and reduce $\delta U_m/\delta E$, which will boost female labour market participation, especially for women with a lower initial bargaining power. Such a dynamic might explain the sudden increase in female wage employment in a region where women were not used to work outside the farm-household, as observed in our case study region.

Further, it is clear from equation (14) that in households with more land and other productive assets, women's reservation wage will be higher as pf_{L_f} will be higher. When preferences for consumption are high – e.g. because of a large number of children in the household – women's reservation wage will be lower.

A fourth equilibrium condition can be derived from substituting equations (12) and (13) in (11) and rearranging:

$$S\begin{cases} = 0 & if\ pf_{L_C} + q > V \\ > 0 & if\ pf_{L_C} + q = V \end{cases} \qquad (15)$$

$$\text{with} \qquad V = \frac{\theta\frac{\partial U_f}{\partial S}+\frac{\partial U_m}{\partial S}}{\theta\frac{\partial U_f}{\partial C}+\frac{\partial U_m}{\partial C}} = pf_{L_f}\frac{\theta\frac{\partial U_f}{\partial S}+\frac{\partial U_m}{\partial S}}{\theta\frac{\partial U_f}{\partial l_f}}$$

This equilibrium condition (15) specifies that households will send their children to school if the benefits from schooling in terms of derived utility are larger than the costs, including a direct cost (q) and an opportunity cost that equals the marginal return to child labour in household production. As long as the costs are larger than the benefits, schooling will be zero. This is in line with human capital theory. Using equation (15) we can examine how female off-farm wage employment affects child education. We can distinguish three different effects. First, there is a general income effect. Female wage income (wE) adds to total income and increases consumption (C). As utility is a concave function of consumption, the marginal utility of consumption, ($\partial U_f/\partial C$) and ($\partial U_m/\partial C$) will decrease. According to equation (15),

the marginal utility of schooling ($\partial U_f/\partial S$) and ($\partial U_m/\partial S$) will need to decrease as well while the marginal return to child labour (pf_{L_C}) increases. This implies an increase in schooling (S) and a decrease in child labour (L).

Second, there is a labour substitution effect. Female wage employment (E) reduces women's leisure time (l_f), their time in household production (L_f), or both. A decrease in women's leisure time will lead to an increase in the marginal utility of leisure ($\partial U_f/\partial l_f$), which according to equation (15) will need to result in an increase in the marginal utility of schooling, ($\partial U_f/\partial S$) and ($\partial U_m/\partial S$), and a decrease in the marginal return to child labour in household production (pf_{L_C}). This implies a decrease in schooling (S) and an increase in child labour (L_c). Likewise, a decrease in women's labour time in household production, will increase the marginal return child labour (pf_{L_C}), leading to an increase in child labour (L_c) and a decrease in schooling (S).

Third, there is an empowerment effect arising from the fact that female wages contribute to women's bargaining power in the household. The factor V is increasing with θ if women's preferences for schooling relative to consumption are larger than those of men $\left(\frac{\partial U_f/\partial S}{\partial U_f/\partial C} > \frac{\partial U_m/\partial S}{\partial U_m/\partial C}\right)$. In this is the case, an increase in θ, resulting from an increase in E, will, according to equation (15), lead to an increase in schooling and a decrease in child labour.

In summary, if women have higher preferences for child schooling than men and if off-farm wage employment empowers women, then the impact of increases in off-farm wage income earned by women on child education will be the result of a positive income effect, a negative labour substitution effect and a positive empowerment effect. The ultimate effect remains an empirical question.

The impact of maternal off-farm wage employment might differ for girls and boys. Parental preferences for schooling might be different for girls and boys. Our model reveals that if the discrepancy in preferences for schooling between women and men is larger for girls than for boys (i.e. $\frac{\partial U_f}{\partial S}\frac{\partial U_m}{\partial C} - \frac{\partial U_m}{\partial S}\frac{\partial U_f}{\partial C}$ is larger for girls), the impact of female off-farm wage employment on child education will be larger (or less negative) for girls. Also, the marginal return to child labour might differ for boys and girls. If a decrease in female labour in household production has a larger impact on the marginal return to child labour for girls than

for boys (i.e. if $pf_{L_c L_f}$ is more negative for girls), than the impact of female off-farm wage employment on child education will be smaller (or more negative) for girls. So, also the differential impact of maternal wage employment on schooling for boys and girls remains an empirical question.

We specifically assumed only women can involve in wage employment outside the household. If men would take up off-farm wage employment, the impact on child schooling would be determined by a positive income effect and a negative substitution effect. Because of the additional positive empowerment effect, female wage employment likely has a larger positive (or a less negative) effect on child schooling than male wage employment.

Other factors might influence child education as well. Land and other productive assets (A) result in higher marginal returns to labour in household production for women, men and children. On the one hand, this increases the opportunity costs of schooling and leads to lower levels of schooling. On the other hand, more productive assets lead to higher income and consumption levels, which lowers the marginal utility of consumption, enlarges the benefits of schooling and leads to more schooling. Other factors such as parental education and demographic characteristics may also affect households' schooling decisions as they determine preferences.

In what follows we will empirically address the question how maternal wage employment in the horticultural export industry in Senegal – and other factors, such as land and non-land assets, parental education and demographic factors – affect child schooling and analyse differential effects for boys and girls.

3. Background and data collection

3.1. Data collection

We use original survey data from the *Niayes* region, the main horticultural region in Senegal where some 20 export companies are located. Data were collected in 2007 using stratified random sampling, resulting in the selection of 451 households in 36 villages in four rural communities. The survey instrument included separate and specific sections for the household head and for the spouse. The survey provides general data on household demographic characteristics, land and non-land asset holdings, agricultural production and marketing, off-farm employment and income, non-labor income, credit and savings. Specifically important for the analysis in this paper is that the survey data include detailed and

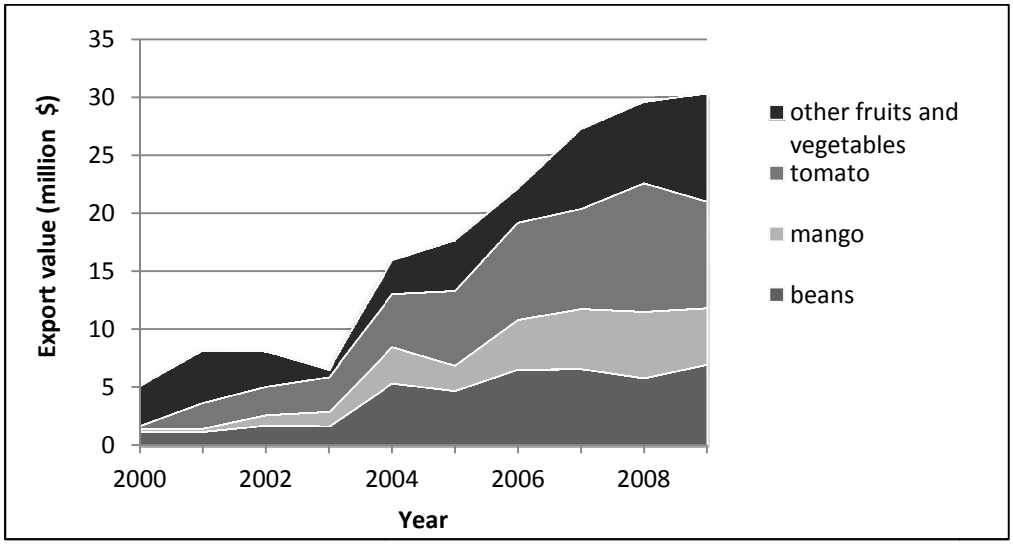
gender disaggregated information on wage employment in the horticultural export industry and associated wage income. In addition, the data allow calculating total household net income from different farm and non-farm sources. Also information on child schooling is available at the individual level for all children between the ages of 6 and 18. This includes information on school enrolment during the past year, the years of schooling and the highest grade obtained. These data allow analyzing school enrolment but more detailed information on school attendance and performance is lacking.

These household data are complemented with original data from a village survey in all selected villages and with secondary village-level data from ANSD (*Agence National de la Statistique et de la Demographie*). This includes information on institutional and infrastructure characteristics such as the presence of a primary school in the village and distances to markets, schools and agro-industrial export companies.

3.2. The horticultural export boom, female employment and child schooling

Horticultural exports from Senegal increased sharply during the past 15 years; from less than 2.5 million US$ in 1995 to more than 30 million US$ in 2009 (Figure 1). The sharpest growth was since the early years 2000. The three main export crops are beans, mangoes and tomatoes of which the first two are mainly sourced from the *Niayes* region. Apart from some small volumes to neighbouring countries, exports are mainly destined for markets in the EU.

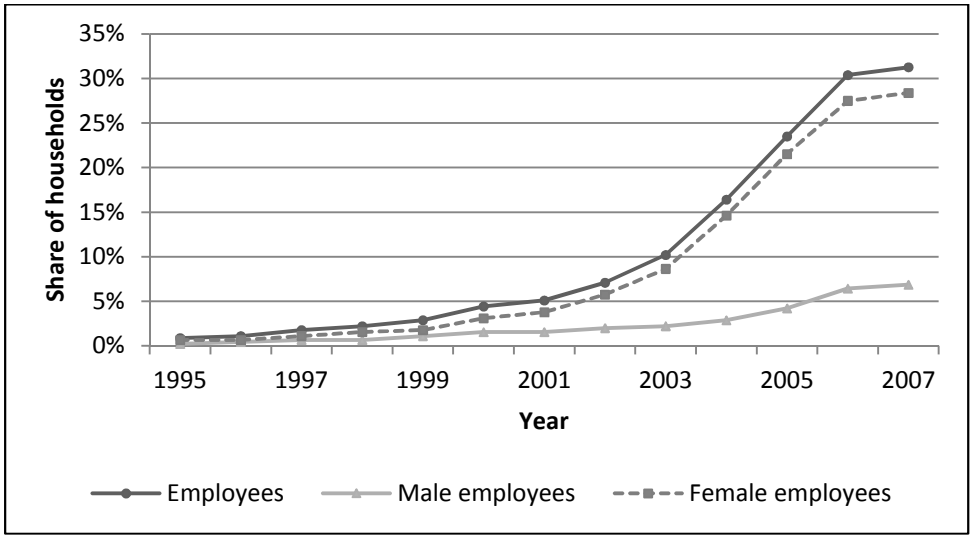
Figure 1: Exports of fruits and vegetables from Senegal, 1995-2009



(Source: derived from Comtrade, 2010)

The horticulture export boom has been associated with increased wage employment on the fields and in the processing and packing units of agro-industrial export companies. Especially since the early years 2000 employment in horticultural export companies increased sharply. This is due to the sharp export growth but also to structural changes in the export supply chain. Due to increasing requirements on traceability, quality and food safety in the EU, horticultural exporters in Senegal shifted their sourcing strategy from relying on contracting with smallholder family farms to vertically integrated estate production based on hired labour[3]. In addition, high quality and safety standards increased the need for labour-intensive post-harvest handling. Importantly, mainly women are employed in the sector. Figure 2 shows that the share of households in the region with one or more members working for wages in the horticulture export industry increased sharply; from less than 5% of households in 2001 to more than 30% in 2007. For the large majority of these households it is specifically female household members who are employed in the agro-industry. Almost one third of rural households in the region have one or several female members working in the agro-industry.

Figure 2: Gender disaggregated participation in wage employment in the horticulture export industry, *Niayes* region, 1995 - 2007



(Source: own calculations from survey data)

The wages women earn in the export agro-industry contribute importantly to total household income. Households with female wage income have significantly higher total incomes, and the wages received by women constitute on average more than one fifth of the total income of these households (Table 1). This has important implications for intra-household bargaining power: 94% of women working as wage laborer in the horticulture

[3] This is explained in detail in Maertens and Swinnen (2009).

agro-industry indicate that this employment increased their decision-making power in the household. It is also important to note that these employment opportunities for women in the horticulture export industry are new: 89% of women working as wage laborer indicate to have never been employed outside the home and the household farm before, and 83% indicate to have no other possibilities for wage employment outside the horticultural export industry. The figures in Table 1 further reveal that household production, mainly farming, constitutes the main part of household income, and that other non-labor sources of income for women are very limited.

Table 1. Household income from different sources across households with and without female wage employment

	total sample	hh with female wage employment	hh without female wage employment	
Number of observations	449	129	320	
Total household income (1000 FCFA)	1,464.85	1,708.65	1,365.96	**
Share of total household income from different sources				
Household farm & non-farm businesses	76%	59%	84%	***
Off-farm wages	18%	35%	10%	***
Female wages from export industry	6.1%	21%	0%	***
Male wages from export industry	1.6%	2.7%	1.0%	**
Non-labour income	6.1%	5.7%	6.2%	
Female non-labour income	1.5%	1.5%	1.5%	
Male non-labour income	4.6%	4.3%	4.7%	

Comparisons are made between household with and without female wage employment using t-test.
Significant differences are indicated with *p < 0.15; **p < 0.10; ***p < 0.05.
(Source: own calculations from survey data)

The horticultural export boom in Senegal has been associated with off-farm employment opportunities for women, sharply increased incomes from wages earned by women and increased bargaining power for women in rural households. The participation of rural women in wage employment in the export agro-industry is likely not randomly distributed across households and depends on observable and unobservable characteristics. We indeed observe some differences in observable characteristics between households with and households without female wage employment (Table 2). The former have significantly more female workers, are better educated, and mainly come from the major ethnic group (Wolof). There is however not much difference between households in terms of ownership of land and non-land assets. Households with female wage employment have higher total landholdings but the difference disappears when accounting for the number of workers. Also unobserved

household and individual characteristics, most importantly initial female bargaining power, may influence women's participation in the labor market.

Table 2. Household demographic characteristics and asset ownership across households with and without female wage employment

	total sample	hh with female wage employment	hh without female wage employment	
Number of female workers	4.34	5.29	3.96	***
Number of male workers	4.52	4.58	4.49	
Number of children age cohort 0 to 6	1.29	1.29	1.29	
Number of children age cohort 7 to 12	1.40	1.47	1.35	
Number of children age cohort 13 to 16	1.15	1.23	1.09	
Age of the household head	54.86	55.67	54.52	
Female headed households (share)	3.3%	3.1%	3.4%	
Ethnic Wolof[1] households (share)	67%	83%	60%	***
Education head, primary (share)	18.4%	25.6%	15.6%	
Education spouse, primary (share)	2.9%	6.2%	1.5%	*
Total landholdings (ha)	3.77	4.27	3.56	*
Landholdings per worker (ha)	0.45	0.49	0.44	
Total livestock units[2]	2.59	2.31	2.69	
Value of productive assets (1,000 FCFA)	332	349	325	

Comparisons are made between household with and without female wage employment using t-test.
Significant differences are indicated with *p < 0.15; **p < 0.10; ***p < 0.05.
[1] Wolof is the main ethnic group in Senegal
[2] One tropical livestock unit (TLU) equals 1 cow, 0.8 donkey, and 0.2 sheep/goat.
(Source: own calculations from survey data)

Before turning to the econometric estimation of the impact of maternal off-farm wage income on child school enrolment, it is useful to compare schooling figures across households. The figures in Table 3 reveal that 57% of primary school-age children in the sample are actually enrolled in school. This rate is higher for boys (60%) than for girls (52%), and higher in households with female off-farm wage employment (65%) than in other households (53%). Also secondary school enrolment and expenditures for schooling are significantly higher in households with female wage employment. The question remains whether the observed differences in primary school enrolment can be attributed to female wage employment and hence whether the boom in horticultural exports has led to positive spillover effects on child schooling.

Table 3. Average school enrolment rates and school expenditures across households with and without female off-farm wage employment

		total sample	hh with female wage employment	hh without female wage employment	
Primary school enrolment	total	57%	65%	53%	**
(age cohort 7-12)	boys	60%	76%	53%	***
	girls	52%	54%	50%	
Secondary school enrolment	total	44%	50%	41%	***
(age cohort 13-18)	boys	48%	64%	41%	***
	girls	38%	35%	40%	
Expenditures for schooling (1,000 FCFA)					
Total expenditures		32.88	46.09	27.55	***
Expenditures per child		10.24	13.67	8.87	***

Comparisons are made between household with and without female wage employment using t-test.
Significant differences are indicated with *p < 0.15; **p < 0.10; ***p < 0.05.
(Source: own calculations from survey data)

4. Econometric methods

To analyse the effect of maternal off-farm wage employment on primary school enrolment we estimate the propensity of each child in the age cohort 7-12 to have attended school during the past year[4] (S). Our main variable of interest is female off-farm wage income from the horticultural export agro-industry[5] (W), which is measured at the household level and specified in four different ways: 1/ a dummy for having female wage income; 2/ total female wage income; 3/ the natural logarithm of total female wage income; and 4/ the share of female wage income in total household income.

In the regression, we additionally control for a large set of individual child characteristics (C) - age, age^2 and gender of the child -, household characteristics (H) - age, gender and ethnicity of the head, education of the head and the spouse, the number of male and female workers and children, land assets, livestock assets, and wealth indicators (dirt floor in the house, use of non-wood energy sources) -, and some village factors (V) - presence of a primary school in the village, distance from the village to the capital city Dakar, and distance to the nearest asphalt road. These covariates capture relevant factors in the model: the availability of labour in the household (the number of male and female workers), the presence of productive assets (land and livestock assets), differences in market prices (distance to roads

[4] This corresponds to the UN definition of net primary school enrolment (United Nations, 2010).
[5] We additionally did the regressions with total female wage income instead of female wage income from the export agro-industry as main dependent variable. We find qualitatively the same and quantitatively very similar effects, which is logic as wages from the export industry constitute the major part of female wage income.

and markets), and the direct cost of schooling (presence of a school in the village). In addition, differences in preferences for consumption, leisure and schooling may be partially captured by the household demographic characteristics, parental education and ethnicity of the household.

$$S = \begin{cases} 1 & if\ S^* > 0 \\ 0 & otherwise \end{cases}$$

$$S^* = \beta_0 + \beta_1 W + \beta_2 2C + \beta_3 H + \beta_4 V + \varepsilon$$

We estimate this model first using a simple probit estimation technique. However, this technique may lead to biased estimates due to unobserved heterogeneity. Initial bargaining power is an important unobserved factor that is likely positively correlated with child schooling, and that, according to the conceptual discussion in section 2, might be positively or negatively correlated with female off-farm wage employment. Hence, with a simple probit model we may over- or underestimate the effect of female wage income on primary school enrolment. Therefore, we use a two stage instrumental variable (IV) estimation technique to account for the endogenous character of female wage income. We have tried different potential instruments that reflect transaction costs for employment in the export agro-industry: 1/ the distance the to the nearest horticultural export company in km, 2/ the total village population, 3/ the share of households in the village with females working in the export agro-industry, 4/ female membership of an organisation in the year 2000, and 5/ the number of small children in the age cohort 0 to 3. These are all relevant instruments as they are highly correlated with female off-farm wage employment. The distance to the nearest export company and the number of small children are negatively correlated with female wage employment. Because women are not allowed to carry children on their back while working in the export companies – they are used to do so when working on their own fields – having small children decreases the likelihood of wage employment. The other potential instruments are positively correlated with female wage employment. Export companies often recruit women through existing organisations, and provide transport from larger villages to their companies during peak labour periods. Hence women from larger villages and women who are member of an organization have a higher probability to be recruited. Yet, some instruments are weak and likely endogenous in the model. We only retained the share of households in the village with females working in the export agro-industry and female membership of an organisation in the year 2000 as excluded instruments. These variables are not correlated with child schooling and have no partial effect on child schooling when

included in the main regression. We specifically use a lagged variable of female organisational membership because the lagged variable is more likely exogenous to the schooling decision than current membership. In addition, using these two instruments, the Angrist-Pischke chi^2 and F-statistics for tests for under identification and weak identification are chi^2=29.04 and F(2,283)=14.01 respectively. In both cases the null hypothesis of under/weak identification can be rejected at the 1% significance level. To estimate the first stage model, we use a probit model for the dummy variable specification and tobit models for the other specifications because female wage income is zero for a substantial part of the observations. Next to the excluded instruments, only the household (H) and village (V) covariates are used in the first stage.

In summary, we use two different models (probit model and an instrumental variable probit model) and four different specifications of the main variable of interest (a dummy variable for female wage income, total female wage income, the log of female wage income, and the share of female wage income in total household income). This allows us to test the robustness of the results. In addition, we estimate the models for all children (701 observations) and for boys and girls separately (374 and 327 observations respectively).

5. Results and discussion

5.1. The effect of female wage employment on child schooling

The regression results with estimated coefficients are reported in appendix, Table A1 (probit model) and A2 (IV probit model). The marginal effects – we report the partial effect at 1 for the dummy variable specification and the average partial effect for the other specifications – for the main variables of interest are summarized in the first column of Table 4.

Table 4. Summary of regression results on the impact of female wage income on the probability of primary school enrolment using different specifications

	Estimated marginal effects[a]											
	ALL CHILDREN				BOYS				GIRLS			
	Probit model		IV probit model		Probit model		IV probit model		Probit model		IV probit model	
Female wage income dummy	0.099	**	0.260	***	0.135	**	0.277	***	0.081		0.224	*
Female wage income	0.025	*	0.061	***	0.045	**	0.079	***	0.015		0.055	**
Share of female wage income	0.157		0.578	***	0.183		0.748	***	0.192		0.523	**
Log female wage income	0.088	**	0.145	***	0.130	**	0.187	***	0.061		0.131	**

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.

[a] Average partial effects are reported, except for the dummy variable specification where the partial effect at 'female wage income dummy = 1' is reported

(Source: own estimations from survey data)

Our main finding is that female wage income from employment in the horticultural export industry has a positive effect on primary school enrolment. In the probit models, the effect is significant at the 5% level for the dummy variable specification and the log specification, and at the 10% level for the other specifications. In the IV probit models, all estimated marginal effects are significant at the 1% level. The estimated marginal effects are higher in the IV probit models than in the probit models. This is consistent with an underestimation of the effect in the probit models, which could result from female bargaining power being negatively correlated with off-farm wage income and positively with child schooling.

The results of the IV probit models indicate that female wage employment increases the likelihood of primary school-aged children to be enrolled in school with 26% points. Likewise, a ten percent increase in female off-farm wage income and in the share of female wage income in total income, increases the likelihood of primary school enrolment with 1.5% points and 5.8% point respectively. These are large and important effects. The estimated effects are in line with insights from the theoretical model that a negative labour substitution effect is offset by a positive income effect and/or a positive empowerment effect.

We also compare the effect of female wage income on the primary school enrolment of boys and girls. The full regression results with estimated coefficients are given in appendix, Tables A3 and A4 (probit and IV probit model for boys) and Tables A5 and A6 (probit and IV probit model for girls). The marginal effects for the main variables of interest are summarized in the last two columns of Table 4. The results of the IV probit models indicate that the effect of female wage employment on primary school enrolment is significantly positive for both boys and girls. The estimated marginal effects are again larger in the IV probit models than in the probit models, especially for girls, and some effects are only statistically significant in the IV probit models. The estimated effects are somewhat larger for boys than for girls but there is no statistical difference in the estimated effects.

These results indicate that the horticultural export boom and associated female wage employment have indirectly contributed to increasing child education, for both boys and girls.

5.2. Comparison with male wage employment

The positive effect of female wage employment on children's propensity to be in school is a combination of an income effect and an empowerment effect. To reveal the importance of these two effects, we compare the results on female wage employment with the impact of male wage employment on child schooling. According to the conceptual analysis in section 2,

when considering male wage employment only the income effect would remain. We consider male wage employment – as 1/ a dummy variable, 2/ male wage income, 3/ the logarithm of male wage income, and 4/ the share of male wage income in total household income – and estimate the same model with probit and IV probit techniques. Because male wage employment in the export industry is relatively low – only 1.6% of households in the sample – we consider in addition total male wage employment, including male wage employment in other sectors. We use the share of households in the village with male wage employment (in the export agro-industry) as excluded instrument to reduce potential endogeneity bias.

Table 5. Summary of regression results on the impact of male wage income on the probability of primary school enrolment using different specifications

	Estimated marginal effects[a]					
	ALL CHILDREN		BOYS		GIRLS	
	Probit model	IV probit model	Probit model	IV probit model	Probit model	IV probit model
Male wage income from the export agro-industry						
Male wage income dummy	-0.098	0.083	0.004	0.202 **	-0.183 **	-0.167
Male wage income	-0.012	0.012	0.017	0.023 *	-0.027 **	-0.003
Share of male wage income	-0.109	0.154	0.102	0.306 *	-0.264	-0.044
Log male wage income	-0.057	0.032	0.002	0.063 *	-0.101 **	-0.009
Total male wage income (from the export agro-industry + other sources)						
Male wage income dummy	0.033	0.259 ***	0.117 **	0.243 ***	-0.070	0.187
Male wage income	0.012 **	0.009 **	0.027 **	0.014 ***	0.004	0.004
Share of male wage income	0.080	0.198 **	0.193	0.300 ***	-0.029	0.080
Log male wage income	0.045	0.047 **	0.095 **	0.071 ***	-0.004	0.019

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.

[a] Average partial effects are reported, except for the dummy variable specification where the partial effect at 'male wage income dummy = 1' is reported

(Source: own estimations from survey data)

The marginal effects for the main variables of interest are summarized in Table 5. The results indicate that total male wage income has a significant positive effect on child schooling in general, with the effect only being significant in the IV probit models. The effects of male wage income on schooling (Table 5) are much smaller than the estimated effects of female wage income (Table 4). A ten percent increase in male wage income and in the share of male wage income in total income, increases the likelihood of primary school enrolment with 0.5% points and 2% point respectively, while this is 1.5% points and 5.8% points for female wage income. This suggests that in the case of male wage employment the income effect prevails while for female wage employment there is an additional large positive empowerment effect. This result corroborates existing empirical evidence on a positive

relation between female bargaining power and child schooling (e.g. Basu, 2006; Gitter and Barham, 2008; Lancaster et al., 2006).

The results in Table 5 further indicate that male wage employment has a significant positive effect on the schooling of boys but not on the schooling of girls. Together with the results in Table 4, this implies that the schooling of boys increases with both higher incomes and higher female bargaining power while the schooling of girls is mainly affected through an empowerment effect, and that this latter effect is larger for girls than for boys. This is in line with earlier studies that found evidence of differential effects of female bargaining power on outcomes for boys and girls. For example, Reggio (2011) observes that only girls' labour time is affected by the distribution of power in Mexican households, while boys' labour time is not. Thomas (1994) provides evidence from the United States, Brazil and Ghana of female bargaining power having a larger impact on the health of girls than on the health of boys. Our findings imply that women have higher preferences for child schooling than men, and that this parental difference in preferences is larger for girls than for boys.

5.3. Other factors

Also other factors have an impact on the probability of child school enrolment. These can be revealed from the full regression models reported in appendix, Table A1 to A6. First, child characteristics matter. We find that children's age has a positive but decreasing effect. This quadratic effect might be specific for our research area where children often enter regular primary school at a later age, after spending one or several years in private Islamic schools. The turning point where school enrolment starts to decrease is around the age of 10, pointing to increased drop-out rates from that age onwards. The results further indicate that the likelihood to be in school is significantly lower for girls than for boys. A calculation of the partial effects for this variable reveals that the likelihood for girls to be in school is about 11% points lower than for boys. This confirms the existing gender imbalance in schooling in rural Senegal.

Second, primary school enrolment is further influenced by household demographic characteristics, ethnicity and parental education. We find that having more brothers decreases a child's own likelihood of being in school. Concerning parental education, our results indicate that both father's and mother's education have a significant positive effect on school enrolment for children in general and for girls, but not for boys. The effect of mother's education is higher than the effect of father's education. This implies that parental education

is especially important for girls' schooling and that mother's education is more important than father's education. Similar effects were found by Glick and Sahn (2000) for urban areas in West Africa and by Reggio (2011) for Mexico but other studies have demonstrated different types of effects. Tansel (1997) found that only father's education determines schooling for both boys and girls in Ghana and Ivory Coast, while Emerson and Souza (2007) indicated that mother's education has a more important impact on schooling (or labour) of daughters while father's education is more important for sons.

Third, also the asset and wealth position of the household is important in determining primary school enrolment. We find that better living conditions (no dirt floor and non-wood energy sources) increases the likelihood of primary school enrolment but the effects are not significant in all model specifications. The wealth position is more important for girls than for boys. This is consistent with a large body of literature pointing to the importance of income and wealth in the demand for schooling. In addition, our results indicate that landholdings have a negative but increasing effect on child schooling, with a turning point around 9 to 10 ha. Such a quadratic effect of land was also observed by Basu et al. (2010); they find that the effect of landholdings on child labour is positive and decreasing, and attribute this to labour market imperfections. The most likely explanation for our finding is that higher landholdings result in a higher opportunity cost of child schooling because of higher returns to child labour in household farm production. Larger landholdings also result in higher income and consumption levels, which at a certain point lead to higher school enrolment.

Fourth, the presence of a school in the vicinity of the village significantly increases primary school enrolment. This is in line with earlier empirical observations; for example with the findings from Tansel (1997) that the distance to the nearest school decreases primary schooling in Ivory Coast and Ghana. Along with the previously discussed results on the effect of wealth and female wage income on schooling, this implies that both the demand and the supply side of schooling are important in increasing primary school enrolment rates in rural areas. The effect of presence of a school in the village is larger for girls than for boys, which implies that also for eliminating gender disparities in primary school enrolment both the demand and supply side of schooling are important. In addition, distance to the road is found to have a positive effect on primary school enrolment. This might be explained by a lower opportunity cost of child education since the marginal return to child labour in farm production is lower further from the road where output prices are lower.

Finally, the results of the first stage probit and tobit models are reported in appendix, Table A7. The two excluded instruments (female membership of an association in 2000, and share of households in the village with females working in the export agro-industry) have a significant effect, which is an indication of the relevance of the instruments. In addition, female off-farm wage income is determined by household demographic characteristics and ethnicity.

6. Conclusion

In this paper we have demonstrated that there are important indirect effects of the boom in horticultural exports from poor countries. We find that through the creation of rural employment for women, the horticultural export sector in Senegal indirectly contributes to increasing primary school enrolment. The effect of female wage employment in the export agro-industry on school enrolment is found to be equally large for boys and girls, but the effect on girl schooling likely mainly comes through increased female bargaining power while the effect for boys comes from both an empowerment and income effect.

Our results imply that the development of the horticultural export sector in Senegal indirectly contributes to the second and third Millennium Development Goals of reaching universal primary school enrolment and eliminating gender disparities in primary education by 2015. This is an important contribution in a country were school enrolment rates lag behind those of Sub-Saharan Africa on average. Our results demonstrate that indirect effects can be important and should be considered in evaluating the contribution of high-value exports on welfare and development.

Apart from female wage income, also parental education and the asset and wealth position of households, are found to be important determinants of primary school enrolment. Our results stress the importance of demand factors in increasing school enrolment rates and hence in reaching universal primary education in poor countries. A main conclusion from our paper is that empowering women in rural households benefits school enrolment rates, especially for girls, and that rural women can be empowered through participation in the labour market. This calls for attention to labour markets in policy strategies on gender and education.

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Appendix

Table A1. Estimation of the probability of children in the age cohort 7-12 to be enrolled in primary school and the impact of female wage income, probit model

	Estimated coefficients of probit models							
Female wage income dummy	0.325	*						
Female wage income			0.080	*				
Share of female wage income					0.498			
Log female wage income							0.280	**
Child age	1.720	***	1.710	***	1.710	***	1.720	***
Child age ^{2}	-0.087	***	-0.086	***	-0.086	***	-0.087	***
Child gender (1=girl)	-0.365	***	-0.375	***	-0.366	***	-0.374	***
Number of male workers	0.035		0.027		0.027		0.032	
Number of female workers	-0.019		-0.021		-0.007		-0.027	
Number of boys	-0.100	***	-0.104	***	-0.101	***	-0.103	***
Number of girls	0.005		0.015		0.014		0.016	
Ethnicity (1=Wolof)	0.243		0.272	*	0.303	*	0.246	
Gender head (1=female)	0.008		0.010		-0.015		0.026	
Age household head	0.006		0.007		0.007		0.007	
Education head (years)	0.436	**	0.454	**	0.465	***	0.434	**
Education spouse (years)	0.887	**	0.929	***	0.931	***	0.900	**
Land owned	-0.075	*	-0.073	*	-0.071	*	-0.076	*
Land owned^2	0.004	**	0.004	**	0.004	**	0.005	**
Livestock units	0.008		0.008		0.007		0.009	
Dirt floor	-0.302		-0.302		-0.326	*	-0.290	
Non-wood energy	0.779	***	0.714	***	0.751	***	0.739	***
School in the village	0.541	***	0.491	***	0.487	***	0.515	***
Distance to Dakar (km)	-0.005	*	-0.006	**	-0.005	*	-0.006	**
Distance to road (km)	0.126	**	0.123	**	0.111	*	0.129	**
Constant	-8.410	***	-8.312	***	-8.383	***	-8.358	***
Number of observations	701		701		701		701	
Log likelihood	-384.9		-385.8		-387.4		-384.5	
Wald Chi^2	126.3		125.9		118.4		132.2	
Prob > Chi2	0.000		0.000		0.000		0.000	
Pseudo R^2	0.205		0.203		0.199		0.206	

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Table A2. Estimation of the probability of children in the age cohort 7-12 to be enrolled in primary school and the impact of female wage income, IV probit model with female wage income instrumented

	Estimated coefficients of IV probit models			
Female wage income dummy	1.033 **			
Female wage income		0.198 ***		
Share of female wage income			1.878 ***	
Log female wage income				0.473 ***
Child age	1.750 ***	1.795 ***	1.790 ***	1.796 ***
Child age ^{2}	-0.088 ***	-0.090 ***	-0.090 ***	-0.090 ***
Child gender (1=girl)	-0.361 ***	-0.376 ***	-0.378 ***	-0.375 ***
Number of male workers	-0.061	-0.131 **	-0.117 **	-0.119 **
Number of female workers	0.058	0.085 **	0.089 **	0.084 **
Number of boys	-0.083 **	-0.078 *	-0.063	-0.073 *
Number of girls	0.006	-0.006	0.005	0.000
Ethnicity (1=Wolof)	0.106	0.001	0.001	-0.004
Gender head (1=female)	0.025	-0.015	-0.015	-0.005
Age household head	0.006	0.008	0.008	0.007
Education head (years)	0.347 *	0.268	0.297	0.253
Education spouse (years)	0.608	0.475	0.400	0.475
Land owned	-0.086 *	-0.113 **	-0.111 **	-0.114 **
Land owned^2	0.005 *	0.007 **	0.007 **	0.007 **
Livestock units	0.010	0.015	0.018	0.016
Dirt floor	-0.226	-0.158	-0.179	-0.165
Non-wood energy	0.835 ***	0.834 ***	0.804 ***	0.872 ***
School in the village	0.700 ***	0.712 ***	0.666 ***	0.734 ***
Distance to Dakar (km)	-0.003	-0.001	0.000	-0.001
Distance to road (km)	0.137 **	0.155 **	0.147 **	0.149 **
Constant	-8.920 ***	-8.322 ***	-8.444 ***	-8.428 ***
Number of observations	701	701	701	701
Log likelihood	-382.9	-378.0	-378.6	-377.9
Wald Chi^2	244.4	264.0	260.9	264.3
Prob > Chi2	0.000	0.000	0.000	0.000
Pseudo R^2	0.209	0.219	0.218	0.219

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Table A3. Estimation of the probability of boys in the age cohort 7-12 to be enrolled in primary school and the impact of female wage income, probit models

	Estimated coefficients of probit models			
Female wage income dummy	0.455 **			
Female wage income		0.143 **		
Share of female wage income			0.571	
Log female wage income				0.413 **
Child age	1.764 ***	1.793 ***	1.815 ***	1.781 ***
Child age ^{2}	-0.089 ***	-0.09 ***	-0.091 ***	-0.09 ***
Number of male workers	0.024	0.017	0.013	0.021
Number of female workers	0.002	-0.005	0.023	-0.009
Number of boys	-0.079 *	-0.086 *	-0.087 *	-0.084 *
Number of girls	0.015	0.026	0.02	0.027
Ethnicity (1=Wolof)	0.156	0.189	0.251	0.161
Gender head (1=female)	-0.298	-0.294	-0.328	-0.278
Age household head	0.000	0.001	0.000	0.000
Education head (years)	0.259	0.274	0.319	0.255
Education spouse (years)	0.668	0.733	0.774	0.686
Land owned	-0.054	-0.053	-0.047	-0.056
Land owned^2	0.003	0.003	0.003	0.004
Livestock units	0.000	0.002	0.000	0.002
Dirt floor	-0.316	-0.295	-0.326	-0.29
Non-wood energy	0.852 **	0.807 **	0.806 **	0.825 **
School in the village	0.471 **	0.394 *	0.392 *	0.429 **
Distance to Dakar (km)	-0.005	-0.006 *	-0.005	-0.006 *
Distance to road (km)	0.102	0.100	0.075	0.106
Constant	-8.308 ***	-8.368 ***	-8.531 ***	-8.326 ***
Number of observations	374	374	374	374
Log likelihood	-207.8	-207.8	-210.2	-207.1
Wald Chi^2	71.8	76.3	66.0	79.1
Prob > Chi2	0.000	0.000	0.000	0.000
Pseudo R^2	0.184	0.184	0.175	0.187

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Table A4. Estimation of the probability of boys in the age cohort 7-12 to be enrolled in primary school and the impact of female wage income, IV probit models with female wage income instrumented

	Estimated coefficients of IV probit models							
Female wage income dummy	1.571	**						
Female wage income			0.257	***				
Share of female wage income					2.432	***		
Log female wage income							0.611	***
Child age	1.825	***	1.867	***	1.861	***	1.869	***
Child age ^{2}	-0.091	***	-0.093	***	-0.093	***	-0.093	***
Number of male workers	-0.058		-0.138	*	-0.119		-0.122	
Number of female workers	0.064		0.095	**	0.100	**	0.094	**
Number of boys	-0.054		-0.052		-0.034		-0.046	
Number of girls	0.010		-0.006		0.006		0.001	
Ethnicity (1=Wolof)	-0.069		-0.163		-0.165		-0.170	
Gender head (1=female)	-0.312		-0.362		-0.364		-0.348	
Age household head	-0.001		0.002		0.002		0.001	
Education head (years)	0.111		0.035		0.075		0.016	
Education spouse (years)	0.221		0.086		-0.007		0.084	
Land owned	-0.069		-0.099		-0.096		-0.101	
Land owned^2	0.004		0.006		0.006		0.006	
Livestock units	0.003		0.008		0.011		0.009	
Dirt floor	-0.195		-0.133		-0.158		-0.141	
Non-wood energy	0.920	**	0.939	**	0.901	**	0.988	***
School in the village	0.710	**	0.676	***	0.616	**	0.705	***
Distance to Dakar (km)	-0.003		0.000		0.001		0.000	
Distance to road (km)	0.115		0.120		0.110		0.113	
Constant	-9.125	***	-8.231	***	-8.392	***	-8.368	***
Number of observations	374		374		374		374	
Log likelihood	-204.6		-202.1		-202.6		-202.0	
Wald Chi^2	61.3		74.8		77.0		74.3	
Prob > Chi2	0.000		0.000		0.000		0.000	
Pseudo R^2	0.197		0.207		0.205		0.207	

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Table A5. Estimation of the probability of girls in the age cohort 7-12 to be enrolled in primary school and the impact of female wage income, probit models

	Estimated coefficients of probit models							
Female wage income dummy	0.284							
Female wage income			0.053					
Share of female wage income					0.653			
Log female wage income							0.208	
Child age	1.753	***	1.716	***	1.694	***	1.740	***
Child age ^{2}	-0.088	***	-0.086	***	-0.085	***	-0.088	***
Number of male workers	0.071		0.062		0.065		0.066	
Number of female workers	-0.066		-0.066		-0.062		-0.071	
Number of boys	-0.133	***	-0.132	***	-0.127	**	-0.134	***
Number of girls	0.005		0.016		0.017		0.016	
Ethnicity (1=Wolof)	0.383	*	0.404	*	0.410	*	0.387	*
Gender head (1=female)	0.520		0.523		0.507		0.536	
Age household head	0.014		0.015		0.015		0.015	
Education head (years)	0.587	**	0.601	**	0.599	**	0.587	**
Education spouse (years)	1.123	**	1.154	**	1.148	**	1.137	**
Land owned	-0.132	**	-0.130	**	-0.130	**	-0.132	**
Land owned^2	0.007	***	0.007	***	0.007	***	0.007	***
Livestock units	0.022		0.020		0.020		0.021	
Dirt floor	-0.376		-0.400		-0.409		-0.383	
Non-wood energy	0.796	**	0.725	**	0.760	**	0.750	**
School in the village	0.755	***	0.712	***	0.708	***	0.735	***
Distance to Dakar (km)	-0.005		-0.005		-0.005		-0.005	
Distance to road (km)	0.151	**	0.146	**	0.144	*	0.151	**
Constant	-9.499	***	-9.320	***	-9.272	***	-9.412	***
Number of observations	327		327		327		327	
Log likelihood	-169.1		-169.7		-169.8		-169.3	
Wald Chi^2	82.6		87.3		86.4		85.7	
Prob > Chi2	0.000		0.000		0.000		0.000	
Pseudo R^2	0.254		0.251		0.251		0.253	

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Table A6. Estimation of the probability of girls in the age cohort 7-12 to be enrolled in primary school and the impact of female wage income, IV probit models with female wage income instrumented

	Estimated coefficients of IV probit models			
Female wage income dummy	0.858 *			
Female wage income		0.190 **		
Share of female wage income			1.812 **	
Log female wage income				0.453 **
Child age	1.787 ***	1.875 ***	1.870 ***	1.875 ***
Child age ^{2}	-0.090 ***	-0.095 ***	-0.094 ***	-0.095 ***
Number of male workers	-0.106	-0.180 **	-0.167 **	-0.168 **
Number of female workers	0.089 *	0.116 **	0.120 **	0.115 **
Number of boys	-0.118 **	-0.112 *	-0.097	-0.108 *
Number of girls	0.011	0.001	0.012	0.006
Ethnicity (1=Wolof)	0.288	0.180	0.177	0.176
Gender head (1=female)	0.555	0.515	0.517	0.524
Age household head	0.015	0.015	0.016	0.015
Education head (years)	0.516	0.432	0.456	0.419
Education spouse (years)	0.912	0.784	0.710	0.783
Land owned	-0.148 **	-0.181 **	-0.179 **	-0.182 **
Land owned^2	0.008 **	0.010 ***	0.010 ***	0.010 ***
Livestock units	0.025	0.031	0.034	0.032
Dirt floor	-0.318	-0.232	-0.252	-0.238
Non-wood energy	0.854 **	0.847 **	0.818 **	0.884 **
School in the village	0.902 ***	0.952 ***	0.907 ***	0.973 ***
Distance to Dakar (km)	-0.003	0.000	0.000	0.000
Distance to road (km)	0.161 *	0.186 **	0.180 **	0.180 **
Constant	-9.994 ***	-9.657 ***	-9.767 ***	-9.758 ***
Number of observations	327	327	327	327
Log likelihood	-168.8	-166.4	-166.5	-166.4
Wald Chi^2	76.7	72.9	72.1	73.0
Prob > Chi2	0.000	0.000	0.000	0.000
Pseudo R^2	0.255	0.266	0.265	0.266

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Table A7. Estimation of first stage probit and tobit models with different measures of female wage income as dependent variable

	Estimated coefficients of first stage probit and tobit models							
	Female wage income dummy		Female wage income		Share of female wage income		Log female wage income	
	probit model		tobit model		tobit model		tobit model	
Number of male workers	-0.113	***	-0.264	***	-0.030	***	-0.109	***
Number of female workers	0.223	***	0.612	***	0.057	***	0.232	***
Number of boys	-0.092	**	-0.162		-0.024	**	-0.078	*
Number of girls	0.023		0.079		0.003		0.021	
Ethnicity (1=Wolof)	0.429	***	1.016	**	0.114	**	0.432	**
Gender head (1=female)	0.210		0.659		0.069		0.254	
Age household head	-0.006		-0.016		-0.002		-0.006	
Education head (years)	0.428	**	1.015	*	0.090		0.459	**
Education spouse (years)	0.259		0.220		0.067		0.093	
Land owned	0.054		0.137		0.014		0.061	
Land owned^2	-0.004		-0.010		-0.001		-0.004	
Livestock units	-0.013		-0.031		-0.005	*	-0.014	
Dirt floor	-0.130		-0.323		-0.035		-0.113	
Non-wood energy	-0.258		-0.066		0.006		-0.107	
School in the village	-0.349		-0.343		-0.015		-0.189	
Distance to Dakar (km)	0.000		0.000		-0.001		0.000	
Distance to road (km)	-0.052		-0.158		-0.012		-0.055	
Female association, year 2000	0.307		0.745	**	0.120	***	0.274	*
Share of female workers in village	2.603	***	5.780	***	0.565	***	2.456	***
Constant	-1.942	***	-5.521	***	-0.481	***	-2.118	***
Number of observations	449		449		449		449	
Log likelihood	-193.20		-428.61		-136.13		-315.67	
Wald Chi^2 (19)	243.16							
Prob > Chi^2	0.000							
F(23, 426)			15.910		13.430		19.540	
Prob > F			0.000		0.000		0.000	
Pseudo R^2	0.283		0.154		0.325		0.194	

Significant effects are indicated with *p < 0.10; **p < 0.05; ***p < 0.01.
(Source: own estimations from survey data)

Chapter 3

Processes of modernization in horticulture food value chains in Rwanda*

1. Introduction

Developing country food systems are changing rapidly with the emergence of so-called modern food supply chains (Gómez et al., 2011; Maertens and Swinnen, 2012; Reardon et al., 2009; Swinnen and Maertens, 2007). These changes are driven by processes of globalization and urbanization, and entail institutional, technical and commercial innovations in food supply chains. Innovations emerge to enable and facilitate the supply to dynamic and demanding global and urban markets, and are usually driven by downstream actors in the chain such as processors, retailers and exporters. These innovations generally result in increased consolidation of the supply base; increased agro-industrialization; increased vertical coordination and inter-linked market transactions; a shift towards higher-value and higher quality products; product differentiation; and increased governance through standards and certification schemes. This modernization process has important implications for rural households in developing countries.

There is a growing body of agricultural economics literature that describes the modernization process, explores the underlying driving forces, and analyzes the consequences for agricultural growth and poverty reduction (e.g. Maertens and Swinnen, 2009; Minten et al., 2009; Rao and Qaim, 2011; Wollni and Zeller, 2007), female empowerment (e.g. Maertens and Swinnen, 2012; Rao and Qaim, 2013), and environmental quality (e.g. Asfaw et al., 2009). These studies focus mainly on export or supermarket supply chains as a 'modern chain' in which innovations occur and benchmark this against the 'traditional chain'. However, in practice a highly diversified landscape of food supply chains exists in developing countries and innovations are not confined to export or supermarket chains, but also emerge in local chains (Humphrey, 2007). For example, smallholder farmers are involved in production for own consumption, for trade in small-scale village markets, for trade in more distant urban

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markets, for direct sales to supermarkets, and for export. Innovations emerge in these supply chains but very few studies have actually differentiated food supply chains beyond the existing, but unrealistic, dichotomy of modern (global) versus traditional (local) chains.

In this paper we describe the horticultural supply chains in Rwanda. We use the value chain concept and original data from stakeholder interviews to characterize and differentiate horticultural supply chains. We show that a wide variety of horticultural supply chains exist, beyond the dichotomy of global versus local chains. We argue that processes of modernization also take place in domestic chains and that there is a gap in the literature on the innovations in these chains and their implications for rural development and poverty alleviation.

2. Methodology

2.1. The value chain concept

The basic definition of a value chain states that "*the value (-added) chain is the process by which technology is combined with material and labor inputs, and then processed inputs are assembled, marketed, and distributed. A single firm may consist of only one link in this process, or it may be extensively vertically integrated*" (Kogut, 1985). A value chain analysis identifies and describes all actors, activities and transactions involved in bringing a product from its conception to its end use (Gereffi et al., 2005; Gibbon, 2003). This analysis entails the identification of different stages and activities within the chain and, within each stage, the role, size and relative importance of all actors. Transactions and coordination between actors in the chain need to be evaluated, taking into account that a wide variety of inter-firm relationships exists between a range of simple market transactions to full vertical integration (Gereffi et al., 2005). The value chain concept has been identified as one of the most useful concepts in characterizing food systems but has been most widely used to describe the participation of farms, firms and countries in global chains of which the activities spread over international borders. In this paper, we use the concept to characterize and differentiate between different horticultural supply chains in Rwanda. We do so by describing aspects of the actors (e.g. type of farmers, type of buyers, degree of consolidation, length of the chain), the activities (e.g. post-harvest value-adding, quality differentiation), and the transactions (e.g. degree of vertical coordination, type of contracts, use of certificates and labels) in the chain. Before turning to this analysis, we describe our data collection and provide background information on the horticultural sector in Rwanda.

2.2. Data collection

After a first explorative field visit in 2010, we collected data from secondary sources and stakeholder interviews in Kigali and the main horticultural regions in Rwanda in 2011. Secondary information includes reports and statistics, collected from the horticulture development authority (RHODA) and the horticulture inter-professional stakeholder organization (RHIO). Original data were collected through structured interviews with actors at different levels of the horticultural supply chain. In total, 40 horticulture producer cooperatives, 18 independent commercial farmers, 6 independent traders, 9 processing companies and 4 exporters were interviewed. A representative sample of processors and exporters was based on secondary information and personal communication with government officials at RHODA and with employees from RHIO. The exporters in our sample were identified during the pre-survey research set-up and no indications were found that other professional exporters exist. In the horticulture survey of 2008, 12 processors were identified (RHODA, 2008). Of these, only 4 still existed at the time of our research with 3 willing to participate. In addition, we selected 6 relatively new companies that were not included in the 2008 survey. Independent commercial farmers, traders and producer cooperatives were selected from a list of horticulture stakeholders provided by RHODA officials. For the cooperatives, a random sample from this list was complemented with a selection of cooperatives specifically supplying processors and exporters, through a snowball sampling procedure. We used a structured questionnaire, including quantitative and qualitative sections with open and closed questions, to interview the different supply chain actors. The structured interviews provide data on business activities in general and on horticultural activities in specific, with details on growth, investments, credit, savings, sourcing and marketing strategies, contracting, interlinked market transactions, certification and labels.

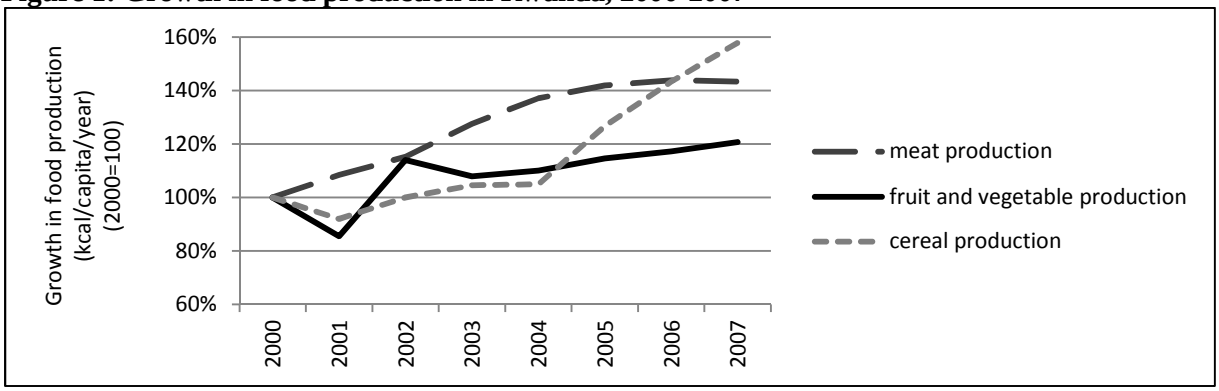
3. The horticultural sector in Rwanda

3.1. Increasing importance

In Rwanda, the development of the agricultural sector is seen as a key engine for economic development and poverty reduction. The sector grew annually with 5% over the period 2006-2010 (World Bank, 2011) and contributed 34% to the total GDP in 2012 (World Bank, 2012). The contribution of the horticultural sector to the GDP has been estimated at 5.2% in 2007 (National Institute of Statistics of Rwanda (NISR), 2008). Overall food production in the country is increasing swiftly. The production of staple foods has grown most strongly, with national production of cereals increasing with 58% over the period 2000-2007. The

production of higher-value produce such as meat, fruits and vegetables increased rapidly over that period, with 43% and 21%, respectively (Figure 1). Estimates suggest that 90% of the food consumed in Rwanda is produced locally. Growth in food production has kept pace with population growth and urbanization. The population grew with 35% over the period 2000-2007, and the urban population increased from 14% in 2000 to 18% of the total population (World Bank, 2012).

Figure 1: Growth in food production in Rwanda, 2000-2007



(Source: derived from FAOSTAT, 2012)

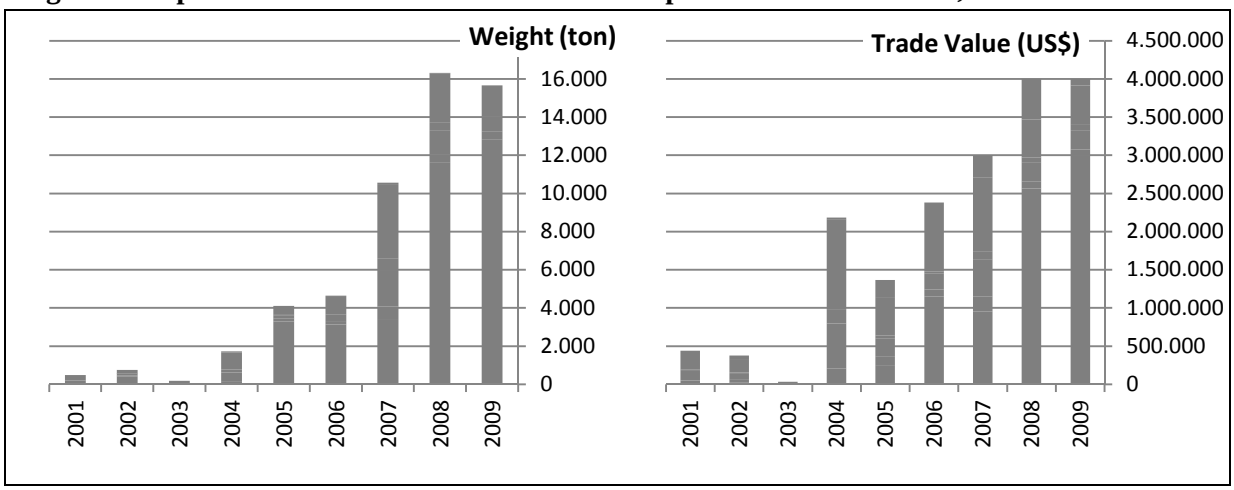
Further, the agriculture sector is an important source of employment in Rwanda, especially for the poorest and least educated segment of the population (NISR, 2008; World Bank, 2011). In 2012, 96% of economically active females and 81% of economically active males were active within the agricultural sector (World Bank, 2012) and the share of wage workers in agriculture doubled between 2001 and 2006, from 4 to 8% of the total working population (World Bank, 2011).

During the last decade, the horticultural sector grew considerably and increased in importance in the activity portfolio of rural households. In the period 2000-2005, the contribution of horticulture to total agricultural production output increased from 3.5 to 12.7% and the acreage where horticulture products are cultivated almost doubled from 2.7 to 5% of the total area under cultivation (RHODA, 2008). Furthermore, in 2008, almost half the population (46%) was involved in horticultural production, and 52% and 40% of households' fruit and vegetable production, respectively, was traded. The main horticultural crops being grown were green beans, cauliflowers, tomatoes, carrots, eggplants, pineapples, passion fruits and Japanese plums (NISR, 2008).

Although the contribution to total exports dropped from 73% in 1996 to 44% in 2009, agricultural exports remain important in foreign exchange earnings. Since 2000, the

contribution of traditional export products, such as coffee and tea, has been decreasing but still accounted for about 85% of total agricultural exports in 2011. The importance of horticultural products in total export earnings remains small, accounting for 4% of agricultural exports in 2011 (World Bank, 2012). However, since 2004, the volume and value of horticultural exports has been steadily increasing (Figure 2), mainly for fresh vegetables, flowers, essential oils and processed food such as canned tomatoes and fruit juices. Yet, the major share of horticultural produce is traded and consumed locally and in urban markets.

Figure 2: Export volume and value of horticultural products from Rwanda, 2001-2009

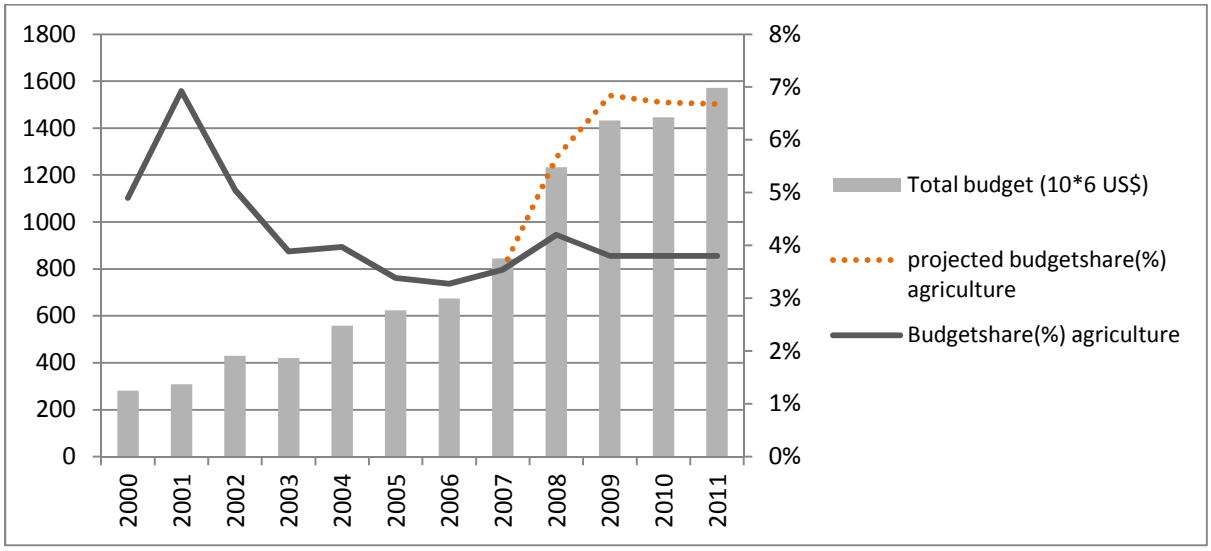


(Source: derived from UN Comtrade, 2010)

3.2. Policies and promotion

Rwanda's agricultural policies and strategies aim at agricultural growth, poverty reduction and food security. Intensification of agricultural production and increased market orientation of the smallholder farm sector play an essential role to achieve these goals (GoR, 2007). The focus is on moving from subsistence farming to a commercial mode of production with intensified use of modern agricultural inputs and technologies, increased specialization in cropping patterns both at the regional level as well as the individual farm level, and professionalization of smallholder farms (GoR, 2011; World Bank, 2011). In 2003, the Government of Rwanda signed the Africa Union's Comprehensive Africa Agriculture Development Program (CAADP) in which an increase of public investments in agriculture to 10% of the national budget was foreseen. Over the past decade, the national budget allocated to the agricultural sector increased steadily but the CAADP goal of 10% budget share to agriculture has not yet been realized (Figure 3).

Figure 3: Total government budget and national budget share for the agricultural sector in Rwanda, 2000-2011.



(Source: derived from MINECOFIN, 2006 and MINAGRI, 2011)

Although coffee and tea are currently still the most important agricultural export crops, the government aims at diversifying commercial agriculture away from a heavy reliance on these traditional export crops. Following the successful examples of horticultural export booms in Kenya, Senegal, South Africa and Ethiopia, Rwanda identified horticultural products as export crops with a high economic potential (GoR, 2004; 2011). Furthermore, 20% of the agricultural budget is allocated to the development of modern food value chains (GoR, 2008) in which the horticultural sector is expected to play a key role.

In order to modernize the agricultural sector, the government encourages value-adding activities and the use of standards in supply chains. In 2002, the government established the Rwandan Bureau of Standards (RBS) that has the responsibility to develop national standards. RBS has put in place phytosanitary inspections for exported (and imported) produce and issues export certificates. The bureau also issues RBS-certificates, including system certificates for quality management, environmental management and food safety management, and product certificates for a standard mark and an excellence mark. Certification is mainly targeted to processing and exporting companies but all certification is voluntary. To obtain the RBS-certificate, food producers, traders and processors must comply with the requirements in terms of product quality, labeling, record keeping and laboratory tests for ingredients and packaging materials.

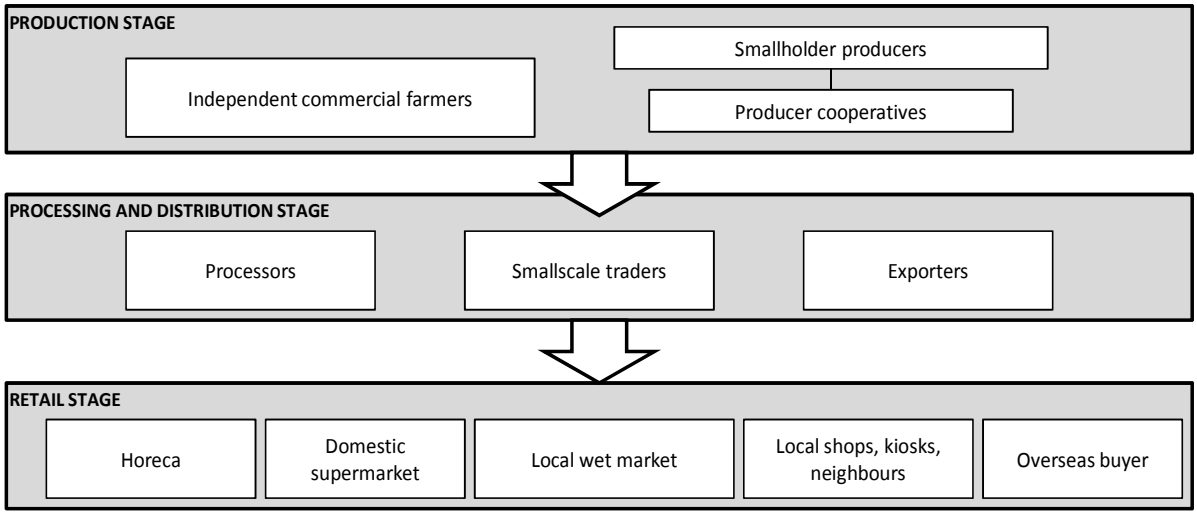
Farmer cooperatives play a very important role in the agricultural sector in Rwanda. According to the Rwanda Cooperative Agency (RCA), *"a cooperative is an autonomous*

association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise, according to internationally recognized co-operative values and principles". These cooperatives are expected to be "*voluntary organizations; open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political or religious discrimination*". Further, cooperative members in Rwanda have equal voting rights (one member, one vote) (RCA, 2011). As presented in the Vision 2020 program, cooperatives are seen as an important vehicle to modernize agriculture through increased intensification and market orientation of the smallholder farm sector. Cooperatives are expected to act as economically productive enterprises. The number of agricultural cooperatives in Rwanda increased sharply during the past years and is estimated at about 2,400 cooperatives. To ensure that farmer cooperatives have access to the markets, the RCA was set up in 2008 for the promotion, registration, regulation and development of cooperatives (RCA, 2011).

4. Value chain analysis

We can distinguish three main stages or levels that include specific actors and activities in horticultural value chains: (i) an upstream level or production stage, including primary producers of horticultural products, (ii) an intermediate level or processing and trading stage, including processors, traders and exporters; and (iii) a downstream level or retail stage, including buyers and retailers. These different stages are presented in Figure 4. We discuss in turn the actors, activities and transactions at the different stages along the supply chain.

Figure 4: Visualization of the different stage in the horticultural supply chains in Rwanda



(Source: based on data from own horticulture professionals' survey, 2011)

4.1. Actors and activities in the chain

Production stage

The main actors at the production stage of horticultural value chains are smallholder producers and independent commercial farmers. Smallholder producers who commercialize horticultural products are scattered over the country and often are organized in cooperatives. The RHODA horticulture survey of 2008 found that one third of all rural households is involved in a cooperative and in half of these cases the cooperatives are involved in horticultural production and marketing (RHODA, 2008). Smallholder farmers in Rwanda generally cultivate less than 1 ha. Horticultural cooperatives usually provide land that is cultivated by the cooperative members. Cooperative landholdings in our sample are on average 38 ha. The crops cultivated on cooperative land are marketed through the cooperative, and usually no side-selling is allowed. Some cooperatives provide their members with credit, technical assistance and inputs such as improved seeds, fertilizers and pesticides.

In the group of independent commercial farms we find commercially-oriented family farms and larger-scale commercial businesses. Independent family farms are owned by private persons (households) who specialize in commercial horticultural activities and mainly rely on family labor. Their farm sizes are relatively small, 3.5 ha on average, but larger than smallholder farm sizes. Larger-scale commercial businesses also specialize in commercial horticulture activities but are more often founded and managed by a group of private persons (investors) and labor is usually hired. These farms are larger, with an average farm size of 9 ha, but are still not of an agro-industrial scale. The capital investments of independent commercial farms are relatively large, on average 34,926 US$ as initial start-up capital. These independent commercial farms are located in the surroundings of Kigali, on average at 53 km from the capital.

Independent commercial farms and smallholder cooperatives cultivate roughly the same type of horticulture crops; vegetables such as tomatoes, cabbages, eggplants and onions or fruits such as pineapples, passion fruits and Japanese plums. Smallholder producers in horticultural cooperatives usually jointly cultivate cooperative fields, but do have private cropping activities on privately owned or rented land. They can have a diversified portfolio of crops and agricultural activities but horticultural cultivation and marketing makes up an important share in their total income. About one third of the producer cooperatives (35%) and more than half the independent commercial farmers (56%) have activities outside horticulture.

These mostly consist of staple food production (grains, cereals and tubers), livestock rearing and dairy production. Nevertheless, there is tendency towards specialization in horticultural production. The large majority of producer cooperatives (90%) and independent commercial farmers (83%) indicate horticulture as their main activity. Horticulture contributes for 82% and 76% to the total revenue of producer cooperatives and independent commercial farmers, respectively, and occupies 82% of cooperative land and 72% of the land of independent commercial farmers.

Some producers perform post-harvest handling and value-adding activities. Smallholder producers do not engage in these activities on their own account, but one fourth of the surveyed producer cooperatives engage in activities such as grading, transformation, washing and packing of produce (Table 1). Grading according to physical characteristics such as size, color and shape is slightly more common for independent commercial farmers; 36% grade their fruits and vegetables after harvest. A small proportion of commercial farmers (14%) perform other activities such as transformation, washing and packaging. Commercial and smallholder producers were asked about the main limitations to horticultural production. A lack of knowledge on production techniques, problems of soil infertility, and losses due to pests and diseases were indicated as being the three main constraints.

Table 1. The importance of value adding activities for different actors in the chain

Value adding activities	Producer cooperative	Independent commercial farmer	Processor	Exporter
Grading	26%	36%	40%	100%
Transformation	26%	14%	100%	0%
Washing	26%	14%	80%	33%
Packaging	26%	14%	100%	100%

(Source: calculations based on data from own horticulture professionals' survey, 2011)

Processing and distribution stage

At the processing and distribution stage, the horticultural chains include processors, exporters and small-scale traders. Processing companies can be quite large businesses, with an average starting capital of 160,000 US$. Processing in the horticulture sector entails the production of fruit juice, jams and canned vegetables such as tomato paste. Exporters engage in trade with overseas buyers and most commonly sell fresh produce, including green beans and chilies. Exporters are less capitalized than processing companies, with initial investment of on average 34,000 US$. The horticultural sector includes a large number of small traders, who buy and sell products in different markets. These are relatively small traders who initially

invested on average 142 US$ in their trading activities. Apart from processing and trading, processors and exporters also engage in primary production of horticultural crops. Half of the exporters and 56% of the processors own or rent in land to cultivate fruit and vegetables. All exporters undertake grading and packaging activities before exporting fresh produce, and some also wash produce (Table 1). Processors engage in transforming and packing products. Grading is less important for processors because for the production of juices, jams, and conserves, horticulture input products are not required to be of premier quality. Small-scale traders do not invest in any value-adding activities. At this level of the chain, companies are highly specialized. Exporters specialize almost completely in horticultural products. Only one exporter has another activity besides horticulture export (grain and dairy trade). Almost half the processors (44%) have other activities but 89% indicate horticulture to be their main business. All small-scale traders in the sample specialized in the trade of horticultural products, notably vegetables.

Retail stage

In Rwanda, a wide array of market outlets is available for (fresh) fruits and vegetables, ranging from traditional wet markets to modern supermarkets. At the retail stage, domestic supermarkets, local wet markets, hotels and restaurants, local shops and kiosks play a role. Regarding supermarkets, there is one leading chain from Kenya with two stores in the capital and one branch of an Ethiopian chain. These foreign based supermarkets tend to import most of their products, even fresh fruit and vegetables that are readily available at local and urban wet markets. Besides, there are a few smaller supermarkets in the capital. These mainly target a higher-income market segment, especially expatriates, with a supply of imported fresh fruits and vegetables that are not readily available on the local market (Belgian endive, celeriac, fennel). Throughout the country, small grocery stores exist, often owned by foreigners. These outlets have a small offer of fresh fruit and vegetables. Little is known about the importance of hotels, restaurants and small local shops for the horticulture sector. However, between 2001 and 2011, the GDP produced by hotels and restaurants increased tenfold from 11 to 111 million US$, representing about 2% of the national GDP in 2011 (NISR, 2011). With a government focus on the development of the tourism sector and its recent growth, it can be expected that the importance of hotels and restaurants as an outlet for horticulture products will increase.

The main retail outlet for (fresh) fruits and vegetables are wet markets. In 2010, national annual retail sales of fruit and vegetables on local wet markets were estimated to be between 150,000 and 180,000 tons. Data from 2010, available from RHODA, show that the five main urban markets in Kigali represent 12% of these market sales and together with other important urban markets in Butare, Gisenyi en Musanze, they account for 17% of wet market sales. Semi-urban and rural markets take up 35% and 48% of wet market sales, respectively. In urban wet markets, traders represent 87% of the suppliers, 7% are producers supplying to these markets. In semi-urban and rural markets, producers represent 9% and 36% of the suppliers, respectively. Furthermore, in urban markets a bigger share of the suppliers come from further away (23% from outside a region of 30 km) while for semi-urban and rural markets this drops to 10% and 3%, respectively. For rural markets, half the suppliers come from a region within 5 km (RHODA, 2010).

4.2. Transactions in the chain

Marketing strategies at the production stage

The produce from horticultural cooperatives and independent commercial farmers is mainly marketed through more traditional outlets, especially through small-scale traders and local wet markets. Selling directly to exporters, processors and supermarkets – often considered as more modern outlets – is still of minor importance for producers. Smallholder cooperatives sell on average 4% of their volume of horticultural produce to exporters, 10% to processors and 2% to domestic supermarkets (Table 2). These volumes are realized by a small number of cooperatives. In our sample of 40 cooperatives, 2 were selling to exporters and 4 to processors. When cooperatives produce for the export market, their entire volume is sold to exporters. Cooperatives selling to processors, sell the major share of the volume (62%) to processors and the remainder to small-scale traders (29%) and in local wet markets (9%). Cooperatives that are not involved in trade with exporters or processors sell on average 41% of their produce on local wet markets, 22% to traders and 29% to local shops and kiosks. None of the larger independent farmers in our sample was selling to exporters and processors. Their main marketing channels are the local wet markets (52% of volume) and traders (31%). A smaller share of the volume (10%) is sold directly to domestic supermarkets (Table 2).

Table 2. Volume of produce marketed through different channels by smallholder cooperatives and independent farmers (volume percentages)

Marketing channel	All producer cooperatives	Producer cooperatives selling to exporters	Producer cooperatives selling to processor	Producer cooperatives selling to traders and retailers	Independent commercial farmers
Exporter	4%	100%	0%	0%	0%
Processor	10%	0%	62%	0%	0%
Domestic supermarket	2%	0%	0%	3%	10%
Horeca	4%	0%	0%	5%	3%
Local shops and kiosks	17%	0%	0%	29%	4%
Trader	28%	0%	29%	22%	31%
Local wet market	34%	0%	9%	41%	52%

(Source: calculations based on data from own horticulture professionals' survey, 2011)

Selling to exporters, processors and supermarkets mostly takes place under contract farming arrangements. All producer cooperatives selling to exporters or to supermarkets have a contract with these buyers and 75% of cooperatives selling to processors do so on a contract basis. Nearly three quarters (67%) of independent farmers selling to supermarkets have a contract. For other marketing channels, contracting exists as well. Half the cooperatives selling to local shops, and 33% of cooperatives and 40% of independent farmers selling to traders have agreements with these buyers. Contracts can be written contracts or oral agreements, and usually stipulate a supply quantity and fixed price. Furthermore, contracts usually entail requirements on quality and appearance, and transport and storage conditions.

Sourcing and marketing strategies at the processing and distribution stage

Exporters rely for 42% of the volume of horticulture produce from own vertically integrated production and the remainder (58%) is sourced from smallholder producer cooperatives (Table 3). Processors rely less on own vertically integrated production (27%) and source from producer cooperatives (33%) as well as from independent commercial farmers (26%) and small-scale traders (19%). They rarely buy produce on the wet market. Traders source produce from producer cooperatives and independent farmers as well as from other traders and on the wet market.

Table 3. Volume of produce sourced from different suppliers by processor and exporters (volume percentages)

	Processor	Exporter
Own production	27%	42%
Producer cooperatives	33%	58%
Independent commercial farmers	26%	0%
Traders	19%	0%
Local wet market	1%	0%

(Source: calculations based on data from own horticulture professionals' survey, 2011)

Exporters work with fewer suppliers and have more stable relations with their suppliers than processors and small traders. On average exporters buy from two different suppliers (who could be cooperatives of smallholder producers). Exporters have at least one supplier from whom they always buy and two thirds of the exporters always work with the same suppliers. Processors have on average nine different suppliers but the majority (80%) also has one supplier from whom they always buy and 57% work with the same suppliers all the time. Traders also have on average 9 suppliers but are more flexible and regularly switch suppliers.

All exporters and processors rely on contracts with suppliers, especially for sourcing from smallholder cooperatives. Some processors do not have contracts to source from independent commercial farmers or traders. Most contracts are formal agreements: 67% and 86% of the exporters and processors respectively use written contracts (Table 4). Contracts mostly specify a fixed price per volume and quality is always specified in terms of appearance with in some cases an additional specification for storage conditions. Contract duration is often not specified. Processors usually do not specify the quantity to deliver while exporters mostly do. Exporters specify and use sanctions in the case contract terms are not met or in case of contract breach. Only 29% of processors do this.

Table 4. Characteristics of contracts with producers for processors and exporters

	Processor	Exporter
Contract type		
- formal (written)	86%	67%
- mix of formal and informal	14%	33%
Contract duration		
- specified	21%	33%
- not specified	57%	66%
Product price		
- fixed price per volume	71%	67%
- not specified	29%	33%
Quality specification		
- appearance	100%	100%
- storage	43%	33%
Quantity to deliver		
- fixed quantity to deliver	14%	33%
- fixed surface to cultivate	0%	33%
- not specified	86%	33%
Services provided to suppliers		
- Technical assistance	86%	100%
- Seeds and/or planting material	86%	67%
- Other inputs	43%	67%
- Sowing services	29%	33%
- Application fertilizers/pesticides	29%	33%
- Harvest services	14%	33%
- Transport	29%	33%
- Credit	14%	33%
Sanctions for contract breach	29%	100%

(Source: calculations based on data from own horticulture professionals' survey, 2011)

Exporters mainly sell to overseas buyers, 56% of the volume they trade (Table 5). They sell the remainder to domestic supermarkets, traders, and local shops. Processors market the majority of their produce (37% of the volume) through domestic supermarkets. The remainder is sold to traders, local shops and on the wet market. Traders sell their produce predominantly on the local wet markets and to other traders (Table 5). Exporters all have contracts with their overseas buyers but not with the buyers they sell to in the domestic market. Processors rarely have a contract with their buyers. Only 1 out of 4 processors selling to domestic supermarkets had a contract.

Table 5. Marketing strategies of modern agribusiness actors in volume percentages

	Trader	Processor	Exporter
Overseas buyer	0%	0%	56%
Domestic supermarket	0%	37%	13%
Horeca	0%	3%	0%
Trader	33%	19%	8%
Local wet market	64%	12%	13%
Local shops and kiosks	3%	28%	10%

(Source: calculations based on data from own horticulture professionals' survey, 2011)

Standards and certificates

The use of standards and certification is becoming more common in the horticultural sector in Rwanda. Even at the production stage, certification has been introduced, but is not yet widespread. Nineteen percent of the producer cooperatives in the sample and 14% of the independent commercial farmers have a certificate. These are all certified to the national RBS certification scheme, which is primarily a phyto-sanitary certificate. No other types of certificates, such as organic or GAP certificates, are observed at the production stage. We specifically asked producers about the benefits that certificates provide. The main perceived benefits for smallholder producer cooperatives and independent commercial farmers are that certification adds value to their products (32% and 18%) and increases access to export markets (26% and 55%). It is not surprising that certification is not very widespread at the production stage of horticultural supply chains as the RBS mainly targets food processing and exporting businesses. None of the small traders in our sample had a certificate; as they stated buyers do not require certificates.

Certification is more common amongst processors and exporters. A large share of processors (80%) and exporters (67%) possesses at least one certificate. All certified exporters have organic certification but surprisingly only half of them had an export certificate. For processors, all certified businesses had RBS-certification. Non-certified exporters and

processors indicated that the process of certification was too expensive and the requirements too difficult to meet.

Rent distribution in the chain

We do not have detailed data to calculate price margins for the different actors at different stages in the supply chains. However, we can reveal something about how rents are distributed in the chain by looking at prices producers receive for produce sold to different buyers. We only take into account fresh produce (including fresh produce sold to processors to be processed), and we standardize the price producer cooperatives get in the wet market to 100 and express all other prices relative to this (Table 6). These analyses reveal that small-scale traders and processors in general pay the lowest prices to horticultural producer cooperatives and independent commercial horticultural farmers. Prices producers receive from traders and processors are only 60 to 90 % of what they receive by directly selling in local wet markets. Cooperatives receive slightly higher prices than in wet markets when directly selling to local shops, hotels and restaurants, and substantially higher prices when selling to domestic supermarkets. Independent farmers receive even higher prices than cooperatives for selling to local shops and domestic supermarkets.

Table 6. Prices for fresh fruits and vegetables in the horticulture value chains

	Buyers							
Suppliers	Local wet market	Trader	Processor	Exporter	Local shops and kiosks	Horeca	Domestic supermarket	Overseas buyer
Producer cooperatives	100	82	57	100	113	105	141	-
Independent farmers	93	91	61	-	160	145	181	-
Exporters	121	-	-	-	-	-	71	629

Prices are standardized, 100 for the price producer cooperatives are getting on the local wet market.
(Source: calculations based on data from own horticulture professionals' survey, 2011)

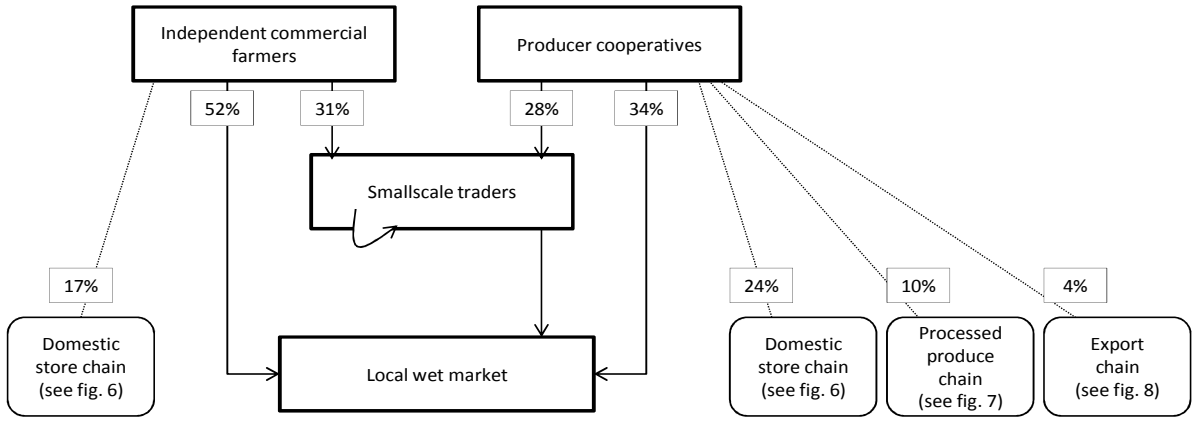
Surprisingly, cooperatives do not receive higher prices when selling to exporters. Prices received from exporters are comparable to those received in wet markets. This is against the expectations as it is generally believed that producers receive a premium over the local price when selling produce for export. Nevertheless, the price exporters receive from overseas buyers is more than six times the price they pay to producers. It is unlikely that this price margin can solely be explained by the costs exporters incur. This might indicate that prices are not transmitted through the chain and that exporters capture high rents. When selling in domestic markets, exporters receive relatively low prices from domestic supermarkets, which

might indicate that exporters sell in local markets lower quality produce that does not meet export standards or produce in excess of what is demanded by overseas buyers.

4.3. Supply chain differentiation

Given this description of actors, activities and transactions in horticultural supply chains in Rwanda, we can differentiate between four different chains. We can distinguish between two domestic fresh produce chains, one domestic processed produce chain and an export chain. First, we can distinguish a 'wet market chain' (Figure 5). Most of the produce that is sold to the consumer in local and urban wet markets is traded by small-scale traders or directly by producers. Different traders might be in between the producers and wet market as many traders sell to or source from other traders. In terms of volume, this is the most important value chain in the horticulture sector as it accounts for 62% of produce that is marketed by smallholder producer cooperatives and 83% of produce that comes from independent commercial farms. Vertical coordination is relatively low in this value chain but some contracting between producers, both cooperatives and independent commercial farmers, and traders is emerging. These contracts are mainly informal, and flexible to enter and exit from both sides. Standards and certificates are not common in the chain but contracts often do entail quality specifications. Apart from grading that is done by producers before selling, there is little value-adding in the chain. However, there is a process of product differentiation and quality grading ongoing and prices in the chain vary according to delivered volumes and produce quality.

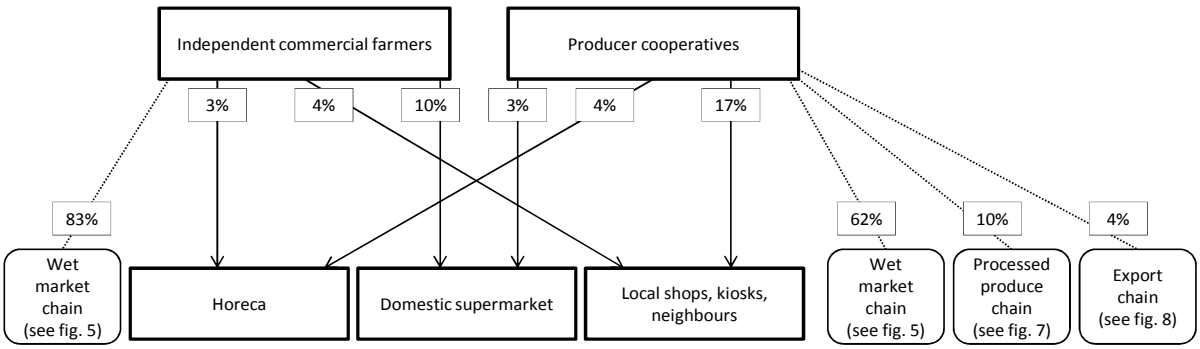
Figure 5: The 'wet market chain': volume shares supplied by producers



(Source: based on data from own horticulture professionals' survey, 2011)

Second, we can distinguish a 'domestic store chain' (Figure 6). These are very short chains in which produce is sold directly by producers to retail outlets such as domestic supermarkets, local shops and kiosks and the hotel and catering industry. In terms of traded volumes, this chain is less important than the 'wet market chain'. Producer cooperatives sell 24% of their volume in this chain and independent commercial farmers 17%. The chain is not dominated by the domestic supermarkets, and local shops and kiosks are at least as important as retail outlet for fresh fruits and vegetables. Contracting is less common in the chain but there are formal written contracts as well as informal agreements, between producers and buyers. Again, standards and certificates are not common in this chain. Interestingly, prices paid to producer are higher in this chain than in the wet market chain. This might be related to the fact that the chain is short without middlemen and traders.

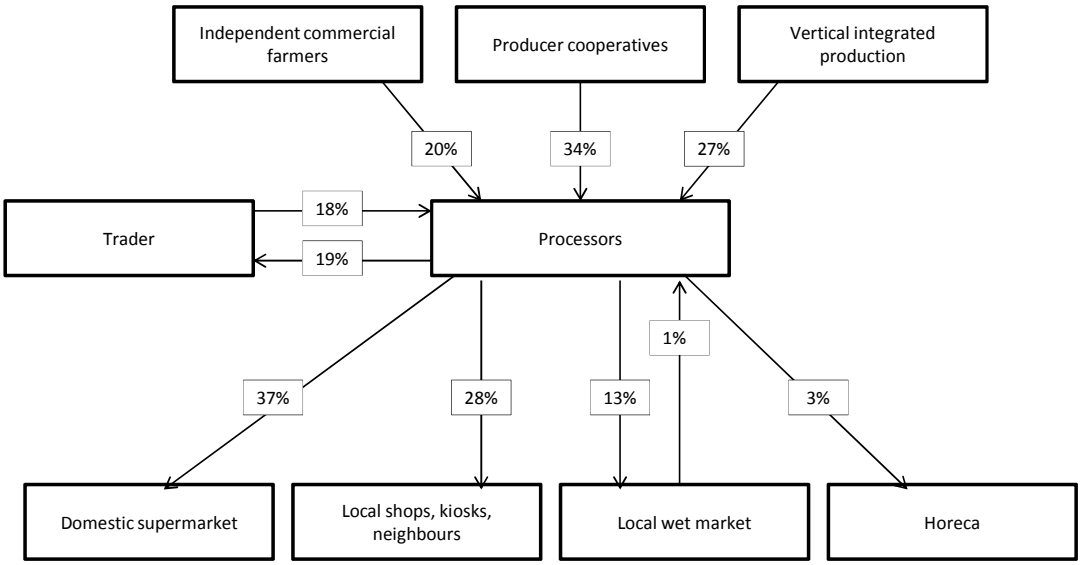
Figure 6: The 'domestic store chain': volume shares supplied by producers



(Source: based on data from own horticulture professionals' survey, 2011)

Thirdly, we can distinguish a 'processed produce chain' (Figure 7) which is based around processing companies. In terms of traded volumes, the chain is less important than the other two domestic chains and accounts for 10% of produce marketed by producer cooperatives. The processors' chain is characterized by a high level of vertical coordination. An important share of the volume for processing comes from processors' own vertically integrated production, and the remainder is sourced mostly under contract-farming arrangements. Processors contract with their suppliers, in a rather flexible way as they often switch suppliers, but not with downstream buyers. Certification is common but there is no differentiation according to quality. Despite a high level of value-adding, farmers supplying this chain receive relatively low prices, even below prices in the 'wet market chain'. Besides less favorable prices, producers selling to processors are confronted with delays in payments; 75% of producer cooperatives selling to processors report continued frequent delays in payment.

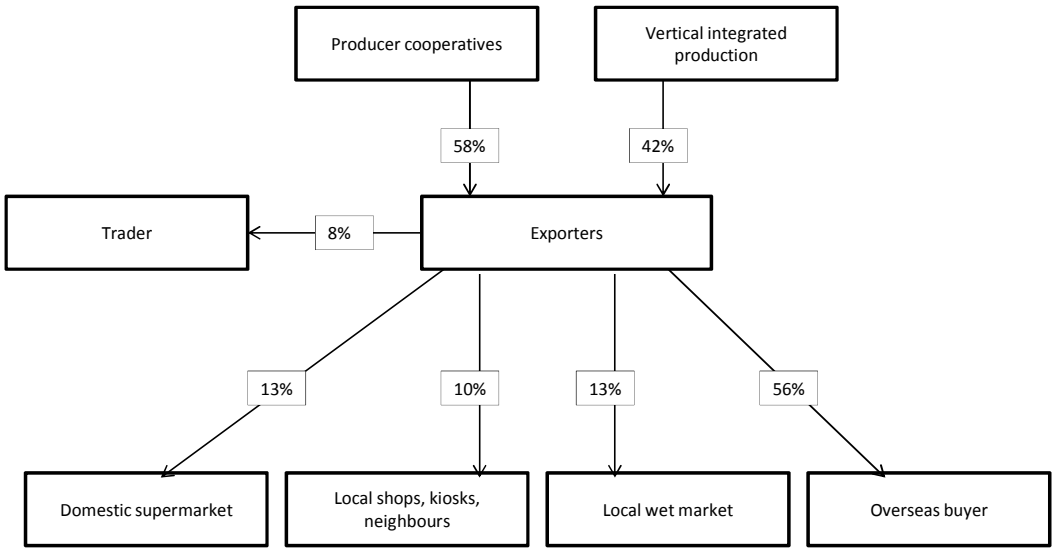
Figure 7: Processed produce chain: volume shares sourced and marketed by processors.



(Source: based on data from own horticulture professionals' survey, 2011)

Finally, we can distinguish an 'export chain' (Figure 8), centered around exporters who sell the largest share of their produce to overseas buyers. In terms of traded volumes, this chain is the least important with only 4% of produce from cooperatives sold through this chain. Vertical coordination is high as the major share of produce is sold under contract with overseas buyers, and virtually all produce either produced by exporters in a vertically integrated way or sourced from producer cooperatives in contract-farming arrangements. Contracts are less flexible than in the other chains, include more quality requirements and entail elements of market interlinking by supplying inputs and assistance to suppliers. The use of standards and certificates is limited to national standards and certification to international standards has not yet taken place. Despite the fact that prices received by exporters from overseas buyers are more than 6 times higher than prices in local wet markets, producers supplying the chain do not receive higher prices. This suggests that there is a problem of unequal rent distribution in the export chain.

Figure 8: Processed produce chain: volume shares sourced and marketed by exporters.



(Source: based on data from own horticulture professionals' survey, 2011)

5. Conclusion

The value chain analysis in this paper shows that in Rwanda a variety of horticultural supply chains exist. The dichotomy of global (modern) chains versus local (traditional) chains that currently exist in the literature does not fit the reality of a diversified landscape of value chains. We also show that processes of supply chain upgrading and modernization, especially value-adding, quality differentiation and vertical coordination, are not confined to export and international supermarket-driven chains but are also ongoing in domestic chains. It is unclear whether these changes in domestic chains are triggered by developing export chains or not. While export chains – the processes of innovation in the chains and the consequences for local farmers – have received most attention in the literature, there is need to better understand innovation processes and their consequences in domestic high-value chains, and the interaction between local and export chains.

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Chapter 4

Cooperative Diversity and Agricultural Performance: Evidence from Rwanda

1. Introduction

Smallholder agriculture remains important for economic development and poverty reduction in developing countries, but its development is challenged by the need for institutional innovations to overcome market failures (Hazell et al., 2010; World Bank, 2008). There is a renewed interest from donors, governments and researchers in cooperative producer organizations as an institutional vehicle to improve smallholder agricultural performance, particularly through improved market participation (Bernard and Spielman, 2009; Fischer and Qaim, 2012a; 2012b). While pre-structural adjustment cooperatives in developing and centrally-planned economies have largely proven to be inefficient and unsustainable (see e.g. Deininger, 1995; Swinnen and Maertens, 2007), contemporary cooperative producer organizations may be different from their predecessors and may benefit smallholder farmers by reducing transaction costs in input and output markets and improving bargaining power vis-à-vis buyers (Bernard and Taffesse, 2012; Markelova et al., 2009).

The literature documents successes and failures of contemporary agricultural cooperatives. A large number of studies show a positive impact of cooperative membership on farm income, farm profits, technology adoption and market participation (e.g. Abebaw and Haile, 2013; Fischer and Qaim, 2012a; 2012b; Francesconi and Heerink, 2010; Holloway et al., 2000; Ito et al., 2012; Shiferaw et al., 2009; Vandeplas et al., 2013; Wollni and Zeller, 2007). But there is also evidence of a lack of success of cooperatives to create benefits for farmers (e.g. Bernard et al., 2008; Bernard and Taffesse, 2012; Hellin et al., 2009; Mujawamariya et al., 2005; Stockbridge et al.; 2003). However, almost all impact studies focus on a single cooperative or on multiple cooperatives in a single sub-sector. Very few studies explicitly look at differences in impact across different cooperatives. Various authors distinguish and characterize different cooperatives; e.g. producer-owned versus investor-owned cooperatives, member-controlled versus state-controlled cooperatives, collective action versus government-initiated cooperatives, open versus closed cooperatives, marketing versus producer

cooperatives, and single-purpose versus multipurpose cooperatives (Sykuta and Cook, 2001). Ito and co-authors (2012) argue that agricultural cooperatives include a wide range of producer organizations but they do not explore potential heterogeneous impacts. Review articles on different agricultural cooperatives in developing countries (Barham and Chitemi, 2009; Markelova et al., 2009) conclude that the success of cooperatives depends on the characteristics of the groups as well as on the type of products and markets. While the heterogeneity among cooperatives is widely recognized, there is almost no quantitative evidence on how this heterogeneity affects the impact cooperatives have on smallholder farm performance. An exception is the study by Fischer and Qaim (2012a) on cooperatives among banana farmers in Kenya; they do look at heterogeneity across cooperative groups and find that older groups perform better because benefits do not occur instantly. There is a need to better understand what type of agricultural cooperatives are most successful in stimulating the development of the smallholder farm sector in developing countries.

In this paper we specifically look at the diversity in agricultural cooperatives in Rwanda. We analyze the impact of cooperative membership on farm performance and analyze the role of cooperative structure and organizational differences to explain impact heterogeneity across different cooperatives. Farm performance is addressed in a broad way, including indicators on agricultural intensification, market orientation, farm revenue and income. We distinguish different types of cooperatives in several ways, for example based on the sub-sector (maize or horticulture cooperatives), or on the labor arrangements within the cooperative (communal or individual). We use several econometric techniques to deal with potential selection bias in estimating the impact of cooperative membership, including a proxy variable method and propensity score matching methods. We find that cooperative membership in general has a positive impact on different farm performance indicators and that effects are driven by specific types of cooperatives.

Rwanda is a particularly interesting case to study the impact of cooperative membership on farm performance. The agricultural sector is of particular economic importance in the country, making up more than one third of GDP and close to 90% of employment in 2012, and is seen as a key growth-engine for economic development and poverty reduction (GoR, 2011; World Bank, 2012). Strategies and policies for agricultural development in Rwanda focus on intensification and increased market orientation of the predominant smallholder farms. Cooperatives are seen as an important vehicle to achieve this and the number of agricultural cooperatives in the country has expanded rapidly during the past couple of years (GoR, 2011;

USAID, 2013). There is however a wide diversity with respect to the types of cooperatives, the way they function, and likely also with respect to their success in promoting intensification, increasing market orientation, and stimulating agricultural growth. Nonetheless, there is little quantitative evidence of the impact of cooperatives on the performance of the smallholder farm sector. Most studies on cooperatives in Rwanda are qualitative studies that focus on the functioning of and entry into cooperatives. Researchers have pointed out that cooperatives in Rwanda are top-down and exclusive, that they undermine land tenure security and investments in improved land management practices (Ansoms, 2009; Ansoms, 2010; Nabahungu and Visser, 2011; Pritchard, 2013). Quantitative evidence on the impact of cooperative membership on farm performance can complement these qualitative insights.

2. Cooperatives and smallholder agriculture

Based on insights from new institutional economics and transaction costs economics we can explore the potential effects of cooperative membership on smallholder farms (Stockbridge, 2003; Sykuta and Cook, 2001). In many developing countries smallholder production and market participation is severely constrained as a result of market imperfections such as missing markets, information asymmetries and high transaction costs (Alene et al., 2008; de Janvry et al., 1991; Goetz, 1992; Staal et al., 1997). Through agricultural cooperatives farmers can overcome some of these market imperfections and constraints, and improve their production and market access (Markelova et al., 2009; Rao and Qaim, 2011; Shiferaw et al., 2009). Through cooperative marketing of produce and joint input purchase, agricultural cooperatives can reduce transaction costs in input and output markets, and increase the bargaining power of small producers vis-à-vis large buyers and input suppliers. This will result in lower input prices, higher producer prices, and higher farm incomes and profits. In addition, reduced transaction costs can lead to improved market access and higher marketed surpluses. Cooperatives can ease the dissemination of knowledge among the members, and some may offer training and extension. This can contribute to the adoption of new technologies and better management practices, which ultimately affects agricultural output, productivity and farm incomes. Some cooperatives may offer financial services, which eases productivity-enhancing investments and leads to higher farm profits.

There are recent examples from all over the world of a positive impact of cooperative membership on these different aspects of farm performance. Ito, Bao and Su (2012) show that

membership in a cooperative has a strong positive effect on the income of watermelon farmers in China. Vandeplas, Minten and Swinnen (2013) find that dairy farmers in India are more efficient and have higher profits when organized in a cooperative. Abebaw and Haile (2013) and Francesconi and Heerink (2010) respectively show that cooperative membership in Ethiopia increases the adoption of improved agricultural technologies, especially mineral fertilizer, and the rate of commercialization. Holloway and co-authors (2000) show that cooperatives increase market participation among dairy farmers in Ethiopia. Fischer and Qaim (2012a) find that cooperative membership leads to higher prices and higher farm incomes among banana farmers in Kenya. Shiferaw, Obare, Muricho and Silim (2009) show that membership in grain cooperatives in Kenya leads to increased adoption of improved varieties, higher producer prices and larger marketable surpluses. Wollni and Zeller (2007) indicate that cooperative membership facilitates access to more lucrative specialty markets in the coffee sector in Costa Rica.

There is a wide variety of cooperatives and the impact of cooperative membership on the performance of smallholder farms likely depends on the type of cooperative (Ito et al., 2012; Sykuta and Cook, 2001). First, cooperatives usually focus on a specific crop, e.g. coffee cooperatives or grain cooperatives, and the type of crop and market may play a role in the success of cooperatives to improve farm performance. It has been argued that cooperatives work better for higher-value crops, such as horticulture crops, than for lower-value staple food crops, such as grains and legumes (Bernard and Spielman, 2009; Markelova et al, 2009). The benefits from collective marketing in staple food crops may be lower than for higher-value crops – and even too low to offset organizational costs – because transaction costs in non-perishable staple food sectors are lower than in higher-value perishable food sectors (Alene et al., 2008; Barham and Chitemi, 2009). In addition, staple food crops are more often sold in local markets where supply chains are shorter and market entry easier while higher-value crops are sold in more distant urban or foreign markets where market access is more difficult. The returns from collective marketing are higher in the latter case. Some review studies indeed indicate that cooperatives are more successful for higher-value crops. For example, Hellin and co-authors (2009) indicate that vegetable cooperatives in Honduras and El Salvador create larger income gains for farmers than maize cooperatives in Mexico that do not improve market access or farm income. Coulter (2007) reviews cooperatives in Africa and concludes that successful cooperatives are more common for higher-value agricultural products but that successful cases of cooperative marketing of grains and root crops do exist.

Second, cooperative structure and organizational differences may matter as well. The composition of the group can be an important factor; more homogenous and older groups may be able to create more benefits. This was pointed out by Fischer and Qaim (2012a) for banana cooperatives in Kenya. The way cooperatives are founded, through collective action by farmers themselves or top-down on government initiative, may play a role as well. Given the failure of the government-initiated cooperative system in centrally-planned economies, collective action organizations are widely believed to be more effective in creating benefits for their member (Deininger, 1995; Murrel, 1991). In addition, there is an important diversity in agricultural cooperatives with respect to the activities for which farmers pool their resources. A broad typology distinguishes between marketing cooperatives, in which marketing of farm output is done cooperatively, supply cooperatives, in which the acquisition of inputs is done cooperatively, and production cooperatives in which farmers pool their land and labor resource to produce collectively. Most studies on the impact of contemporary agricultural cooperatives focus on marketing cooperatives while others do not explicitly state which type of activities are cooperatively organized in the cooperatives under study.

Despite the fact that some studies point to the importance of diversity in cooperatives, there is almost no quantitative evidence on how this diversity affects the impact cooperatives have on smallholder farm performance.

3. Case study and data collection

We use original household survey data collected between February and March 2012 in Muhanga, an administrative district in the Southern province of Rwanda. Explorative field visits in 2010 and 2011 revealed that the district of Muhanga hosts a variety of agricultural cooperatives, with a clear distinction between cooperatives involved in cereal (maize) production and marketing, and cooperatives involved in horticulture.

A three-stage stratified random sampling technique was used and resulted in the selection of 401 households. In the first stage, we selected 16 cooperatives. Based on government reports and personal communication with local government officials and the local cooperative support organizations, we identified 26 active cooperatives in the district. We stratified these according to where cooperatives sell their produce, namely: cooperatives only selling at local wet markets and the urban market in Muhanga (the provincial capital); cooperatives also selling to traders from more distant markets; and cooperatives with experience in selling to

processing companies and exporters. We randomly selected cooperatives from these strata: 7 out of 12 from the first group, 5 out of 10 from the second group, and all 4 from the last group. In the second stage, we identified the villages where these 16 cooperatives are active and made a random selection of 40 villages (*imidugudu*) out of 61. In the third stage, we stratified households in these villages according to cooperative membership, and selected 263 cooperative member households, belonging to 16 different cooperatives, and 138 control households. Cooperative members were oversampled –meaning their share in the total population is lower than their share in the sample– because of our specific interest in the different cooperatives. To correct for this oversampling, we use sampling weights in our descriptive analysis. These are calculated as the inverse of the probability of being selected in the sample, using information from the cooperatives and from detailed census data. While cooperative members account for 65% of the households in the sample, they make up 28.8% of the population when sampling weights are taken into account. For the analysis in this paper, we use 389 households. We dropped 12 cooperative member households from the sample because the cooperative they indicated to belong to, is not known and not included in the list of 26 cooperatives active in the district.

We developed and used a quantitative structured questionnaire, including different modules on household demographic characteristics, land and non-land asset holdings, agricultural production, cooperative membership, off-farm employment and income, non-labor income, food security, intra-household decision-making, and savings and credit. Some of these modules – e.g. on food security and intra-household decision making, were specifically directed to the spouse, who was interviewed separately. A final and specific module of the questionnaire included a bidding game. With this game we elicited respondents' willingness to pay (WTP) to become a cooperative member. The bidding game was implemented with both actual cooperative members and non-cooperative members and makes use of the answer of each respondent on a hypothetical question about cooperative membership, whether that respondent is a cooperative member or not. As there is a variety of cooperatives active in the area, we refer to a specific cooperative in the game. This is the cooperative they are member from for actual cooperative members and a selected cooperative that is prevalent in the village for non-cooperative members. We use an iterative bidding game that involves a sequence of dichotomous choice questions, in which the highest bid is set at 200,000 RWF[1] and the lowest at 1,000 RWF[2]. The highest bid corresponds to the

[1] 200,000 RWF corresponds to about 310 Euro; 1,000 RWF corresponds to about 1.55 Euro.

highest actual membership fee among the cooperatives in the survey area. The iterative bidding game method has been widely used by other economists (e.g. Frew, 2004; Whittington et al., 1993) and has been proven to be a suitable and reliable technique in developing countries (Dong et al., 2003; Onwujekwe and Nwagbo, 2002; Whittington 1998).

The household survey data were complemented with data from a survey among the 16 selected cooperatives. This includes data on cooperative activities, investments, credit, sourcing and marketing strategies, and organizational set-up.

4. Cooperatives in Rwanda

4.1. Importance of cooperatives

As mentioned in the introduction, cooperatives are seen as an important vehicle to increase intensification and market orientation of the smallholder farm sector, and the number of cooperatives is expanding rapidly. In 2008, Rwanda had approximately 1,500 registered cooperatives[3] of which 43% active in agriculture, and 186,000 cooperative members of which 54% in an agricultural cooperative. Agricultural cooperatives are most prevalent in the horticulture, coffee and maize subsectors (Table 1).

Table 1. Registered cooperatives in 2008, by economic activity

	Cooperatives	Members
Total (#)	1,498	186,131
Agriculture	43%	54%
- horticulture cooperatives	26%	7%
- coffee cooperatives	19%	19%
- maize cooperatives	12%	15%

(Source: derived from ILO, 2010)

According to the latest (unofficial) estimations, the number of cooperatives has increased to 5,000, compromising about 2.5 million members (USAID, 2013) and about 2,400 agricultural cooperatives (MINECOFIN, 2007). The overall number of cooperatives is likely to further increase as all pre-cooperative associations are required by law to register as official cooperatives (ILO, 2010).

[2] One may object that assuming the first "yes" answer to the sequential bids used in the game is not equal to a respondent's actual WTP but since the responses to the contingent valuation question are used here as proxy variable rather than an actual precise measure of WTP what matters for this approach is to capture the variation in marginal utility derived from cooperative membership between respondents.

[3] According to the Rwanda Cooperative Agency, "*a cooperative is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise, according to internationally recognized co-operative values and principles*". Cooperatives are expected to be "*voluntary organizations; open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political or religious discrimination*". Cooperative members in Rwanda have by law equal voting rights (one member, one vote) (RCA, 2011).

The National Land Policy (GoR, 2004) has played a role in the establishment of cooperatives. Specifically for the cultivation of the fertile and highly-productive marshlands, the regulation stipulates these areas as a special category of public, thus state-owned, land with usufruct rights in the form of concessions and with the allocation responsibility within the Ministry of Lands and Environment. Land consolidation projects have been introduced to avoid parceling of this valuable agricultural land. Cultivation of the marshlands is regulated by the government and only accessible for official cooperatives. The Government of Rwanda believes these measurements are necessary to move from "*a mediocre agriculture that has no future, characterized by tiny plots on which the prevailing crops are sweet potatoes, sorghum and beans for domestic consumption*" towards improved (mode of) production on marshlands with technical innovations (GoR, 2004). Besides access to productive marshland areas, cooperatives also play a role in distributing subsidized inputs, especially fertilizer (World Bank, 2010). With an average mineral fertilizer use of 8kg/ha in 2007, the government encouraged increased fertilizer application, by distributing inputs through rural cooperatives and service providers at subsidized prices and estimates suggest, that as a result of this effort, national use increased to 23kg/ha in 2010 (MINAGRI, 2011).

4.2. Maize and horticulture cooperatives

There is a large diversity among agricultural cooperatives in Rwanda. Besides the focus on different crops, there are marketing cooperatives, producer cooperatives and intermediate forms of cooperatives. Cooperatives differ in size, with regard to the number of members and/or the area under cultivation. Cooperatives can be founded voluntarily by farmers' collective action or can be government-initiated. We focus on maize and horticulture cooperatives and first explore the difference between these two types of cooperatives, using cooperative and household survey data.

In Table 2 we summarize some general cooperative characteristics of the 5 maize and 11 horticulture cooperatives, and the 134 maize and 117 horticulture cooperative members in our sample. Maize cooperatives are on average larger than horticulture cooperatives, with larger initial capital investments, more members, and larger cooperative field sizes. The membership fee in both types of cooperatives is similar but is now much higher than at start-up, which relates to the fact that members already have invested in the cooperative during the past years and that new members are expected to compensate for this. All maize cooperatives and half of the horticulture cooperatives are government-initiated while the other horticulture cooperatives emerged through collective action. Comparing cooperative members, we observe

that on average, members of a horticultural cooperative joined more recently – 2.8 years ago compared to 5.8 years for maize cooperative members – and paid a lower initial membership fee – 2.8 thousand RWF compared to 6.1 thousand RWF.

Table 2. Characteristics of maize and horticulture cooperatives and cooperative members

	Maize cooperatives (n=5)	Horticulture cooperatives (n=11)
Average initial capital investment (RWF)	2,030,600	174,545
	(2,717,570)	(237,175)
Number of members in 2011 (#)	460	37
	(296)	(31)
Total cooperative field size in 2011 (ha)	74.20	3.44
	(67.23)	(2.82)
Membership fee at start-up (RWF)	4,400	2,958
	(3,715)	(2,360)
Membership fee in 2011 (RWF)	29,750	24,000
	(30,467)	(16,287)
Initiative to start-up cooperative		
- government-initiated	100%	50%
- collective action	0%	50%
Time of existence (years)	2.8	4.2
	(1.5)	(1.7)

	Maize cooperative members (n=134)	Horticulture cooperative members[1] (n= 117)
Member since (yrs)	5.8	2.8**
	(5.79)	(2.77)
Membership fee paid to coop. (RWF)	6,091	2,784***
	(5,828)	(4,561)
Yearly contributions paid to coop. (RWF)	1,617	1,110
	(1,893)	(2,586)
HH head is member (dummy)	66%	32%***

Notes: Mean values are shown, for continuous variables standard deviations are shown in parentheses
[1] Horticultural cooperative members are compared with maize cooperative members using t-test, *, ** and *** denote 10, 5 and 1% significance level
(Source: calculations based on data from own cooperative survey, 2012)

The production and marketing arrangements differ in some aspects across the cooperatives. In fact, all cooperatives under study act as 'land cooperatives', meaning that cooperative members collectively purchase or rent in land, either from private land-owners or from the state. For maize cooperatives, the cooperative land is completely rented in from the state. This mostly concerns marshlands that are state-owned since the new land policy of 2004. For horticulture cooperatives, about half of the cooperative land is rented from the state, 43% is rented from private land-owners and 6% is purchased and owned by the cooperative. Apart from the cooperative land, farmers usually also cultivate their own plots which they own or rent in individually. The way production on cooperative land and marketing of the produced crops is arranged differs across the cooperatives. In all maize cooperatives, members are

allocated a specific part of the cooperative land that they cultivate individually[4]. Maize cultivation is characterized by a synchronized planting and harvesting regime. Once harvested, the produce from cooperative plots is sold through the cooperative – 4 out of the 5 maize cooperatives explicitly do not allow side-selling. Post-harvest handling and storage is organized jointly and controlled by regional state-agronomists. In 3 out of the 5 maize cooperatives, the members are paid per kg maize they harvested and delivered to the cooperative. In the other cooperatives, farmers are either paid collectively in cash or in kind, equally divided over the cooperative members, or the revenues from selling maize are kept within the cooperative as savings. After the maize season, members are free to cultivate other crops on the collective plots allocated to them. They often grow vegetables during this second season and the revenues from selling these vegetables can mostly be kept by the farmers – in one case the cooperative collects a tax on these revenues. Given that land is obtained collectively, production organized individually, and marketing organized collectively, the maize cooperatives in the sample could be broadly categorized as 'land and marketing cooperatives'.

In nine horticulture cooperatives, the members cultivate the cooperative land collectively. In this case, all produce is sold through the cooperative and members are either paid a collective share of the revenue, either in cash or in kind (respectively three and two cooperatives), or the revenues are kept within the cooperative as savings (four cooperatives). As production on cooperative land is organized through communal labor, these cooperatives can be broadly categorized as 'land and production cooperatives'. In the other two horticulture cooperatives, the members individually cultivate an allocated part of the cooperative land, there is no cooperative marketing for the horticultural products, and members keep individual revenues from marketing these products, either with or without paying taxes to the cooperative. These cooperatives act as 'land cooperatives' where only land acquisition is done collectively.

Most cooperatives offer some services, especially the provision of agricultural inputs, to their members. In one maize cooperatives and three horticulture cooperatives agricultural equipment, such as hoes and shovels, is put at the disposal of the members. The majority of cooperatives, three maize and eight horticulture cooperatives, give some form of credit to

[4] Marshlands that are state-owned and cultivated by cooperatives used to be under private tenure before the new land policy of 2004. The specific plots allocated to and cultivated by individual cooperative members might correspond to the plot previously owned by that farmer.

their members. Six horticulture cooperatives and three maize cooperatives organize trainings for their members. All maize cooperatives provide improved seeds and mineral fertilizers, either at subsidized prices (four cooperatives) or for free (one cooperative), while only seven out of the 11 horticulture cooperatives provide improved seeds and only three mineral fertilizer. The provision of pesticides by the cooperatives is less common. The high level of input provision in maize cooperatives is in line with the national policy in which cooperatives are given an important role for the distribution of improved seeds and mineral fertilizers.

When asked about their overall satisfaction with the cooperative, 76% of maize cooperative members and 63% of horticulture cooperative members indicate to be satisfied. Reasons for that satisfaction include a good internal organisation, good cooperation among members, and the access to inputs and services. Reasons for dissatisfaction with the cooperative include the lack of (financial) transparency and delay in payments. Of the non-member households, 74% would like to be a member of a cooperative for varying reasons such as to have access to land (46%), to be organised with friends (44%), to have access to information (42%) and to have access to credit and modern inputs (29% and 24% respectively). Reasons for not being member of a cooperative for these households, include the lack of sensibilisation and awareness about cooperative formation (21%), high membership fees (17%), lack of land to contribute to the cooperative (31%), and lack of time (21%). Twenty percent of non-member households would not like to be a cooperative member and the most quoted reasons for that are a lack of advantages from cooperative membership (33%), lack of land (19%), and lack of time or labour to work in a cooperative (32%).

4.3. Cooperative members and non-members

Before turning to an econometric analysis of the impact of cooperative membership on farm performance, it is useful to compare household and farm characteristics between member and non-member farm-households and between maize and horticulture cooperative members. This is done in Table 3. This comparison shows that cooperative member households have a relatively older household head and more household members that work in agriculture but there are no significant differences between member and non-member households with regard to the household size, the composition of the household, the gender composition of the labor force, the education of the household head, and the number of siblings close by (as a measure of social capital). When comparing maize and horticulture

cooperative members, there is not much difference in demographic characteristics, apart from horticulture cooperative members having a higher share of female workers.

Land- and livestock holdings are quite small in the sample, on average households only own 0.27 ha of agricultural land and 1.1 tropical livestock units. Cooperative members own significantly more land and livestock than non-cooperative members while there is no difference in land and livestock ownership between members of maize and horticulture cooperatives. Households differ substantially with respect to total and per capita household income. The household income of cooperative members is 60% larger than that of non-members, and the income of maize cooperative members 52% larger than that of horticultural cooperative members. The income from farming makes up on average 50% of total household income, and is a lot higher for cooperative members – 380,593 RWF compared to 169,693 RWF for non-members. Also farm income per worker and gross farm revenue are higher among cooperative members. There are no differences in farm income and revenue between maize and horticulture cooperative members. When looking at farm practices, we observe that cooperative members in general and maize cooperative members in specific, sell a larger share of farm produce, spend more on inputs and use more modern technologies such as improved seeds, mineral fertilizer, pesticides and irrigation.

Whether these observed differences in farm income, farm revenue, share of produce sold and use of modern inputs is the result of cooperative membership has to be revealed through a more in-depth econometric analysis.

Table 3. Household and farm characteristics according to cooperative membership

	Total sample (n=389)	Non-member households (n=138)	Member households[1] (n=251)	Maize cooperative (n=134)	Horticulture cooperative[2] (n=117)
Demographic characteristics					
Female single headed (dummy)	0.22	0.25	0.13	0.11	0.23
HH head age (years)	45.61	44.34	48.76**	49.02	47.73
	(13.3)	(13.86)	(11.33)	(11.8)	(9.33)
HH head education (yrs)	4.86	4.73	5.16	5.39	4.28
	(2.9)	(2.71)	(3.31)	(3.2)	(3.6)
HH size (#)	5.03	4.93	5.29	5.22	5.56
	(2.06)	(1.99)	(2.19)	(2.33)	(1.53)
HH size children (#)	2.53	2.57	2.44	2.35	2.80
	(1.74)	(1.74)	(1.74)	(1.81)	(1.41)
HH size agricultural workers (#)	1.92	1.73	2.38***	2.38	2.41
	(0.98)	(0.85)	(1.13)	(1.17)	(0.95)
% female workers	54%	53%	55%	53%	61%**
	(20)	(20)	(19)	(18)	(21)
Siblings living close (#)	2.1	2.0	2.4	2.5	2.4
	(2.5)	(2.5)	(2.4)	(2.5)	(2.0
Household assets and income					
Land individually owned (ha)	0.27	0.22	0.38**	0.35	0.54
	(0.50)	(0.44)	(0.60)	(0.54)	(0.80)
Livestock (TLU)	1.1	0.8	1.8***	1.8	1.4
	(1.1)	(0.8)	(1.4)	(1.5)	(1.0)
Total income (RWF)	465,650	398,636	630,319**	677,741	443,690*
	(446,434)	(297,308)	(659,728)	(668,568)	(594,133)
Income/per adult equivalent (RWF)	107,344	94,938	137,827***	150,143	89,357***
	(95,170)	(67,643)	(137,257)	(134,908)	(136,880)
Farm characteristics					
Farm income (RWF)	230,695	169,693	380,593***	401,821	297,053
	(307,925)	(179,353)	(466,643)	(498,073)	(305,789)
Farm income per worker (RWF)	122,874	100,205	178,578**	190,775	130,578
	(166,581)	(93,913)	(264,744)	(287,410)	(138,447)
Gross farm revenue (RWF)	220,409	158,636	372,202***	396,221	277,675
	(270,454)	(152,059)	(405,052)	(431,988)	(258,806)
Land cultivated individually (ha)	0.30	0.25	0.43**	0.39	0.57
	(0.50)	(0.36)	(0.71)	(0.64)	(0.93)
Cooperative land cultivated (ha)	0.030	0.00	0.10***	0.10	0.09
	(0.09)	(0.00)	(0.14)	(0.16)	(0.07)
Share of produce sold	25.7%	20.3%	39.1%***	43.5%	21.7%***
	(26)	(24)	(25)	(24)	(21)
Input use (RWF)	13,252	7,648	27,114***	31,263	10,839***
Use of improved seeds	57%	43%	90%***	97%	64%***
Use of mineral fertilizer	52%	37%	89%***	97%	58%***
Use of pesticides	36%	23%	67%***	76%	36%***
Use of irrigation	33%	21%	62%***	70%	35%***

Notes: Mean values are shown, standard deviations are shown in parentheses

[1] Cooperative members are compared with non-members using t-test, *, ** and *** denote 10, 5 and 1% significance level

[2] Horticultural cooperative members are compared with maize cooperative members using t-test, *, ** and *** denote 10, 5 and 1% significance level

(Source: calculations based on data from own household survey, 2012)

5. Econometric approach

To assess the impact of cooperative membership on farm performance in more detail, we estimate regression models of the following type:

$$Y_i = \theta + \alpha D_i + \beta X_i + \varepsilon_i, \forall i \quad (1)$$

The dependent variable in the model, Y_i, measures the farm performance of household i. We think about farm performance in a broad way, including agricultural intensification, market orientation, farm revenue and income. We use different performance indicators and estimate the model separately and independently for each indicator: 1) farm income[5] (log specified), 2) farm income per agricultural worker (log specified), 3) gross revenue from farm production[6] (log specified), 4) the share of farm produce sold, 5) total value of agro-inputs (including fertilizers, pesticides, seeds), 6) use of improved seeds, 7) use of mineral fertilizer, 8) use of pesticides, and 9) application of irrigation practices. The latter four indicators are binary variables, for which probit models are used, while the former are continuous variables, for which linear regression models are used. Our main variable of interest in equation (1) is D_i, a binary treatment variable for cooperative membership, either cooperatives in general or specific types of cooperatives.

As cooperative membership is likely not randomly distributed in the population, we need to be aware of selection bias. We use four different methods and models to reduce potential bias and identify the impact of cooperative membership on farm performance as accurately as possible. First, as in equation (1) we include a large vector of control variables, X_i, in the regression to reduce potential bias arising from observed heterogeneity being correlated with the error term. These include household demographic characteristics, household asset ownership, a social capital indicator and a market access indicator – as described in Table 4.

[5] Annual farm income is calculated as the value of crop and livestock production (including non-marketed produce valued at market prices) minus variable production costs (including purchased inputs, hired labor, land rent, etc.). Revenue transfers from the cooperatives are also added to the farm income while cooperative contribution costs are subtracted.

[6] Gross farm revenue is calculated as the value of crop and livestock production (including non-marketed produce valued at market prices) and transfers from the cooperatives.

Table 4. Control variables

Variable	Description
Demographic characteristics	
Female single HH	Dummy for single, female-headed households
HH head age (yrs)	Age of the household head in years
Square of HH head age	
HH head education (yrs)	Years of education of the household head
HH agricultural workers (#)	Number of agricultural workers in the household
HH children (#)	Number of children (age < 18 years) in the household
Asset ownership	
Land owned (ha)	The total area owned by the household, expressed in hectares
Square of land owned	
TLU	The number of tropical livestock units (TLU) possessed by the household
Social capital	
Siblings living close (#)	The number of brothers and sisters of the household head and his/her partner living close by
Market access	
Distance to the market (min)	The mean distance to the market, expressed in minutes of walking distance, of the plots under cultivation

Second, we use a proxy variable to capture some unobserved effects. Unobserved heterogeneity can cause the variable D_i to be arbitrarily correlated with the error term, leading to selection bias in estimated coefficients. There might be various sources of unobserved heterogeneity, like differences in entrepreneurship, ability, motivation and risk preferences between cooperative members and non-members. Inspired by the work of Bellemare (2012), we use the household's WTP to become a cooperative member as additional control variable in the regression (see equation 2) to proxy for unobserved effects and mitigate unobserved heterogeneity bias. Households' WTP was estimated through a bidding game, as explained above. The WTP measure is a reasonable proxy for unobserved factors like ability, motivation and entrepreneurship. It is likely redundant – meaning it is irrelevant for explaining farm performance if cooperative membership and unobserved ability, motivation and entrepreneurship would be controlled for (Wooldridge, 2002). In addition, WTP captures the variation in marginal utility derived from cooperative membership – or treatment in general (Bellemare, 2012) and is likely to be closely related to unobserved ability, motivation and entrepreneurship such that potential correlation between the X's and the error term is reduced in equation 2 (Wooldridge, 2002). As unobserved factors such as ability and motivation are likely positively correlated with both cooperative membership and farm performance, we expect this method to lead to more conservative estimations of the main effects.

$$Y_i = \theta + \alpha D_i + \beta X_i + \gamma WTP_i + \varepsilon_i, \forall i \quad (2)$$

Third, we consider the selection bias as a sample selection problem and apply propensity score matching (PSM) to estimate the average treatment effect (ATE) of cooperative membership. This involves matching cooperative members or treated households with non-members or control households that are similar in terms of observable characteristics (Angrist and Imbens; 1996; Imbens, 2004; Caliendo and Kopeinig, 2008). We estimate the propensity score (PS) as the probability of being a cooperative member, using the vector X as conditioning factors (see equation 3). We apply kernel matching[7], using the default Gaussian kernel, and match treated units (cooperative members) to a construct that is the weighted average of all control units (non-members) with weights depending on the propensity score distance between treated and control units. Then the ATE is calculated as the average of the outcome differences between treated Y(1) and matched controls Y(0) (Dehejia and Wahba, 2002; Imbens, 2004) (see equation 3).

$$PS = P(D=1|X)$$

$$ATE = E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)] \quad (3)$$

The reliability of propensity score matching estimators depends on two crucial assumptions. First, the conditional independence assumption requires that given observable variables, potential outcomes are independent of treatment assignment (Imbens, 2004). This implies that selection into treatment is based entirely on observable covariates, which is a strong assumption. Second, the common support or overlap condition requires that treatment observations have comparison control observations nearby in the propensity score distribution (Caliendo and Kopeinig, 2008). We address these assumptions with robustness checks and the propensity score overlap and balancing properties in annex 2. As proposed by Heckman et al. (1997) only observations in the common support region – where the propensity score of the control units is not smaller than the minimum propensity score of the treated units and the propensity score of the treated units not larger than the maximum propensity score of the control units – are used in the analysis.

Fourth, we repeat the PSM approach, using both X_i and WTP as conditioning variables in estimating the propensity score (see equation 4). In this way, unobservable characteristics are to some extent taken into account in matching cooperative members with non-members. We use the same kernel matching method as above.

[7] With kernel matching all information from all control units is used, which is an advantage because our sub-sample of control units is not very large.

PS= P(D=1|X, WTP)

$$ATE = E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)] \quad (4)$$

We first use these four techniques – 1) OLS regression on X, 2) OLS regression on X and WTP, 3) PSM with X as conditioning factors, and 4) PSM with X and WTP as conditioning factors – to estimate the impact of cooperative membership in general. Since we are specifically interested in cooperative diversity, we then use the same four techniques to estimate the impact of membership in maize and horticultural cooperatives. We do these estimations separately for the two types of cooperatives in order to be able to compare OLS estimates with PSM estimates. This allows us to reveal whether there are differences in impact of cooperative membership according to the type of crops and markets.

We further explore heterogeneity across cooperatives by additionally classifying cooperatives according to their structure and organizational characteristics. First, we classify the cooperatives according to the labor arrangements for agricultural production: 1) horticulture cooperatives with individual cultivation, 2) horticulture cooperatives with communal cultivation, and 3) maize cooperatives with individual cultivation. The latter group cannot be split up further as none of the maize cooperatives rely on a communal production system. Second, we classify the cooperatives according to how revenues are distributed among the members: 1) cooperatives with individual payment for the quantity produced, 2) cooperatives with collective payment as share of total revenue, and 3) cooperatives where revenues are saved and invested in the cooperative. To reveal the impact for these different classes of cooperatives, we only use OLS estimation techniques 1 and 2 because PSM methods are not robust and balancing properties not satisfied for these small sub-samples of treated observations. So, we estimate equations (1) and (2) on the full sample of observations and with D_i being a vector of dummy variables representing different types of cooperatives.

6. Results and discussion

6.1. Maize and horticulture cooperatives

The estimated effects for the main variable of interest, i.e. cooperative membership, are given in Table 5 for all cooperatives, and in Tables 6 and 7 for maize and horticulture cooperatives, respectively. The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP), model 3 (PSM with X as conditioning factors) and model 4 (PSM with X and WTP as conditioning factors). The full

regression results for model 1 and 2 for selected outcome indicators and for maize and horticulture cooperatives are, for completeness, given in annex 1 but are not discussed in the text. The robustness checks for the PSM models 3 and 4 are given and discussed in annex 2. We need to note that, in most cases, the estimated coefficients of cooperative membership are higher in model 1 than in model 2, which indicates that without including the WTP variable, the effect of D_i on the performance indicators is overestimated. As the WTP variable is used as a proxy for unobserved factors, such as ability and motivation, that are likely positively correlated with both cooperative membership and farm performance, including this proxy variable leads to more conservative estimates – as we expected. Likewise, the estimated effects of the PSM methods in model 3 and 4 are mostly lower than the effects in regression models 1 and 2 respectively, which is in line with PSM methods generally giving more conservative estimates (Wooldridge, 2002).

The results in Table 5 show that cooperative membership in general has a strong positive effect on farm performance. We find that participation in a cooperative improves market orientation; resulting in an increase in the share of farm produce sold of 10 to 16 percentage points. In addition, cooperative membership results in increased agricultural intensification. We find large and significant positive effects on the value of inputs – effects range between 6 and 8.6 thousand RWF and are significant at the 5 or 1% level – and on the likelihood of using improved seeds, mineral fertilizer, pesticides and irrigation – marginal effects are between 21 and 31percentage points, except for pesticides where effects are somewhat lower, and are all significant at the 5 or 1% level. Cooperative membership also has a positive effect on gross farm revenue, net farm income and farm income per worker. Taking the most conservative results, participation in cooperatives increases gross farm revenue with 37%, net farm income with 25% and farm income per worker with 27%, which are large effects.

Table 5. Estimated effects of cooperative membership on farm performance

Dependent variables	Model 1	Model 2	Model 3	Model 4
log (farm income)	0.34**	0.33**	0.25**	0.29**
	(0.13)	(0.15)	(0.11)	(0.12)
log (farm income/worker)	0.30**	0.28*	0.27**	0.27*
	(0.13)	(0.14)	(0.12)	(0.15)
log (gross farm revenue)	0.52***	0.43***	0.37***	0.38***
	(0.11)	(0.12)	(0.11)	(0.13)
Share of farm produce sold	0.16***	0.14***	0.15***	0.10**
	(0.03)	(0.03)	(0.03)	(0.04)
Value of inputs used (RWF)	8,682***	7,138**	8,672***	6,033***
	(3,070)	(3,310)	(1,765)	(1,785)
Use of improved seeds (dummy)	0.26***	0.21***	0.23***	0.21***
	(0.04)	(0.05)	(0.05)	(0.05)
Use of mineral fertilizer (dummy)	0.29***	0.25***	0.23***	0.24***
	(0.05)	(0.05)	(0.06)	(0.07)
Use of pesticides (dummy)	0.21***	0.19***	0.13**	0.16**
	(0.05)	(0.06)	(0.05)	(0.06)
Use of irrigation (dummy)	0.27***	0.22***	0.31***	0.29***
	(0.05)	(0.06)	(0.06)	(0.06)

Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP), model 3 (PSM with X as conditioning factors) and model 4 (PSM with X and WTP as conditioning factors).
For model 1 and 2, estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables. For model 3 and 4, the ATE is reported. Standard errors are shown in parentheses. Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 389, of which 251 cooperative member and 138 control households.
(Source: calculations based on data from own household survey, 2012)

When analyzing the impact of maize and horticulture cooperatives on farm performance separately (Table 6 and 7), it becomes clear that positive findings are mainly driven by maize cooperative membership. While membership in maize cooperatives increases agricultural intensification, commercialization and farm income, membership in horticulture cooperatives has a less pronounced effect on farm performance. The results in Table 6 show that membership in a maize cooperative has a positive significant effect on all performance indicators. Taking the most conservative estimates, we find that participation in maize cooperatives increases farm income with 35%, farm income per worker with 33%, gross farm revenue with 36%, the share of produce sold with 14 percentage points, and the value of inputs with 7.7 thousand RWF. It also increases the likelihood of using improved seeds, mineral fertilizer, pesticides and irrigation with 35, 39, 15 and 35 percentage points respectively. These are large and important effects, indicating that in the case of maize cooperatives, cooperative membership contributes to improving the performance and wellbeing of smallholder farmers in Rwanda.

Table 6. **Estimated effects of membership in maize cooperatives on farm performance**

Dependent variables	Model 1	Model 2	Model 3	Model 4
log (farm income)	0.68***	0.62***	0.50***	0.35**
	(0.18)	(0.20)	(0.15)	(0.17)
log (farm income/worker)	0.65***	0.60***	0.49***	0.33**
	(0.18)	(0.20)	(0.14)	(0.14)
log (gross farm revenue)	0.73***	0.58***	0.47***	0.36***
	(0.15)	(0.17)	(0.12)	(0.13)
Share of farm produce sold	0.20***	0.17***	0.22***	0.14***
	(0.04)	(0.04)	(0.04)	(0.05)
Value of inputs used (RWF)	12,670***	9,247*	12,568***	7,787**
	(4,723)	(5,268)	(3,872)	(3,621)
Use of improved seeds (dummy)	0.44***	0.40***	0.35***	0.38***
	(0.06)	(0.06)	(0.07)	(0.08)
Use of mineral fertilizer (dummy)	0.54***	0.47***	0.39***	0.41***
	(0.06)	(0.06)	(0.07)	(0.08)
Use of pesticides (dummy)	0.26***	0.26***	0.15**	0.17**
	(0.06)	(0.07)	(0.07)	(0.09)
Use of irrigation (dummy)	0.42***	0.35***	0.45***	0.46***
	(0.06)	(0.07)	(0.08)	(0.07)

Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP), model 3 (PSM with X as conditioning factors) and model 4 (PSM with X and WTP as conditioning factors).
For model 1 and 2, estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables. For model 3 and 4, the ATE is reported. Standard errors are shown in parentheses. Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 271, of which 133 maize cooperative member and 138 control households
(Source: calculations based on data from own household survey, 2012)

Horticulture cooperatives are less successful in creating gains for their members. The results indicate that membership in horticulture cooperatives significantly increases intensification and commercialization but has no effect on returns and farm income. We find that participation in horticulture cooperatives increases the value of inputs with 3.6 thousand RWF and the share of produce sold with 7.7 percentage points. These effects are substantially smaller than the effects found for maize cooperatives. In addition, based on model 2 which gives the most conservative results, we find that there is no effect on the likelihood of using modern inputs, on gross farm revenue and farm income.

Table 7. Estimated effects of membership in horticulture cooperatives on farm performance

Dependent variables	Model 1	Model 2	Model 3	Model 4
log (farm income)	0.030	0.0394	0.226	0.195
	(0.172)	(0.182)	(0.174)	(0.205)
log (farm income/worker)	-0.0206	-0.0180	0.174	0.131
	(0.171)	(0.181)	(0.202)	(0.244)
log (gross farm revenue)	0.328**	0.237	0.466***	0.365**
	(0.140)	(0.147)	(0.132)	(0.148)
Share of farm produce sold	0.117***	0.0928***	0.108***	0.0770*
	(0.0328)	(0.0344)	(0.0378)	(0.0429)
Value of inputs used (RWF)	4,419***	3,693**	5,195***	4,123**
	(1,486)	(1,569)	(1,879)	(1,863)
Use of improved seeds (dummy)	0.133**	0.0899	0.207***	0.158*
	(0.0629)	(0.0667)	(0.0762)	(0.0888)
Use of mineral fertilizer (dummy)	0.116*	0.0830	0.143*	0.112
	(0.0661)	(0.0704)	(0.0813)	(0.0804)
Use of pesticides (dummy)	0.102*	0.0813	0.114*	0.114*
	(0.0559)	(0.0591)	(0.0651)	(0.0649)
Use of irrigation (dummy)	0.116*	0.0829	0.183***	0.193***
	(0.0647)	(0.0694)	(0.0604)	(0.0632)

Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP), model 3 (PSM with X as conditioning factors) and model 4 (PSM with X and WTP as conditioning factors).
For model 1 and 2, estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables. For model 3 and 4, the ATE is reported. Standard errors are shown in parentheses. Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 256, of which 118 horticulture cooperative member and 138 control households
(Source: calculations based on data from own household survey, 2012)

Our findings that maize cooperatives in Rwanda have a positive effect on different farm performance indicators, are in line with earlier results in the literature on a positive impact of cooperative membership (e.g. Holloway et al., 2000; Shiferaw et al., 2009; Francesconi and Heerinck, 2010; Fischer and Qaim, 2012a; Ito et al., 2012; Abebaw and Haile, 2013). Our finding that maize cooperatives have a much higher impact on farm performance than horticulture cooperatives does not correspond with the prevalent view in the literature that cooperatives are most successful for higher-value products (Barham et al., 2009; Bernard and Spielman, 2009). Most previous studies have indicated positive effects of cooperative membership for products such as fruits, dairy and coffee, and a lack of impact of cooperative membership for grain and legume crops (Bernard et al.,2008; Bernard and Taffesse, 2012); except for Shiferaw and co-authors (2009) who document positive effects of grain cooperatives on technology adoption in Kenya. It is not very likely that differences in findings are solely related to the type of crop and its characteristics in terms of value, perishability, quality differentiation, etc. Our results might be related to differences in the maize and horticultural markets in Rwanda. The market for maize is well established with a structured trading system, many traders and millers, and substantial government support. The market for horticultural crops is less developed and started to receive government support more recently.

The characteristics of the cooperatives themselves likely also matter to explain the observed heterogeneity in impact between maize and horticulture cooperatives. As discussed in section 4, there are important differences between the two types of cooperatives. Maize cooperatives are larger and older (Table 2). It has been argued that smaller (and more homogenous) groups function better because of more cohesion, but that larger groups can achieve economies of scale (Markelova et al., 2009; Fischer and Qaim, 2012a); our results seem to support the latter argument. The longer experience (or maturity) of maize cooperatives might also partially explain their better outcome. In addition, maize cooperatives are all government-initiated while half of the horticulture cooperatives are initiated through collective action (Table 2). It has been argued that the institutional arrangements in government-initiated cooperatives are problematic because rules and regulations are imposed rather than developed by the members themselves (Sykuta and Cook, 2001; Markelova et al., 2009). Previous research has criticized the top-down approach in Rwandan cooperatives (Ansoms, 2009; 2010; Pritchard, 2013) but our results indicate that government-initiated cooperatives can have a strong positive impact. Our findings might be related to the fact that maize cooperatives receive more government support, e.g. through subsided input programs. The provision of services, especially free or subsidized input provision, differs between the cooperatives and is more prevalent in maize cooperatives than in horticultural cooperatives. This likely contributes to explaining the differences in estimated effects on intensification and input use between maize and horticulture cooperatives.

6.2. Differences in cooperative arrangements

Besides, also the way cooperatives function likely plays a role in explaining the observed heterogeneity in impact between maize and horticulture cooperatives. As discussed in section 4, maize cooperatives function more as ‘land and marketing cooperatives’ – where land is obtained through the cooperative but where production is done individually – while horticulture cooperatives are more ‘land and production cooperatives’ – where land obtained through the cooperative is cultivated communally. Also the remuneration system differs, with maize cooperative members being more often paid individually per kg of produce delivered and horticulture cooperative members being more often remunerated through collective pays. These arrangements importantly affect farmers’ incentives and might contribute to explaining the observed differences in impact of cooperatives membership. We explore this heterogeneity in labor arrangements and remuneration system across cooperatives in Table 8 and Table 9 respectively.

The results in Table 8 indicate that horticulture cooperatives with an individual cultivation system perform as well as the maize cooperatives. We find that membership in a horticulture cooperative with individual labor has a significant positive effect on farm income, on labor productivity, on gross farm revenue, on commercialization, and on the likelihood to use improved seeds, mineral fertilizer, pesticides and irrigation. In addition, the magnitude of these effects is comparable to that of the effects of maize cooperatives. This indicates that differences in cooperative arrangements, rather than the type of crop, determine the impact of cooperative membership on farm performance. Only for the value of inputs used, there is no significant effect of membership in a horticulture cooperative with individual cultivation, while there is a significant positive effect of membership in a maize cooperative. This might relate to the government support in subsidized inputs for maize cooperatives.

In addition, we find that horticulture cooperatives with a communal cultivation system do not create much benefit for their members. Membership in such a cooperative significantly increases gross farm revenue, the value of inputs used, and the likelihood of using improved seeds, but the effects are much smaller in magnitude than the effects of membership in a horticulture or maize cooperative with individual labor. In addition, we find that there are no significant gains in terms of farm income and labor productivity from membership in horticulture cooperatives with communal labor.

The results in table 9 point to differences in the impact of cooperative membership on farm performance, related to the remuneration system of the cooperatives. We find significant positive effects of cooperative membership on all performance indicators for cooperatives where members are paid individually per kg of produce supplied to the cooperatives. Also for cooperatives where revenues are saved or invested in the cooperative, we find significant positive effects on farm income, labor productivity, gross revenue, commercialization, and the likelihood to use modern inputs – although the magnitude of the effects is somewhat lower – but not for intensification. For cooperatives in which members are remunerated in a collective way, we only find a significant positive effect of membership on the share of produce marketed and not for any other performance indicator.

Table 8. Estimated effect of membership in horticulture cooperatives with communal cultivation and maize and horticulture cooperatives with individual cultivation on farm performance

	Maize cooperative		Horticulture cooperative with individual cultivation		Horticulture cooperative with communal cultivation	
Dependent variables	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
log (farm income)	0.477***	0.564***	0.494*	0.511**	0.198	0.223
	(0.150)	(0.165)	(0.256)	(0.256)	(0.156)	(0.157)
log (farm income/worker)	0.451***	0.517***	0.427*	0.440*	0.133	0.153
	(0.149)	(0.165)	(0.254)	(0.255)	(0.156)	(0.157)
log (gross farm revenue)	0.519***	0.511***	0.679***	0.677***	0.389***	0.387***
	(0.123)	(0.136)	(0.218)	(0.219)	(0.129)	(0.131)
Share of farm produce sold	0.226***	0.185***	0.141**	0.133**	0.097***	0.085**
	(0.032)	(0.035)	(0.056)	(0.056)	(0.033)	(0.033)
Value of inputs used (RWF)	14,297***	12,249***	3,824	3,427	2,781	2,182
	(3,508)	(3,870)	(6,205)	(6,208)	(3,679)	(3,708)
Use of improved seeds (dummy)	0.363***	0.343***	0.357***	0.353***	0.132**	0.126**
	(0.052)	(0.059)	(0.111)	(0.111)	(0.053)	(0.053)
Use of mineral fertilizer (dummy)	0.425***	0.420***	0.489***	0.488***	0.083	0.082
	(0.051)	(0.058)	(0.119)	(0.119)	(0.058)	(0.058)
Use of pesticides (dummy)	0.258***	0.248***	0.182*	0.179*	0.075	0.072
	(0.053)	(0.059)	(0.098)	(0.098)	(0.062)	(0.062)
Use of irrigation (dummy)	0.368***	0.326***	0.558***	0.549***	0.086	0.074
	(0.052)	(0.060)	(0.113)	(0.112)	(0.063)	(0.064)

Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP).
For model 1 and 2 estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables.
Standard errors are shown in parentheses. Significant effects are indicated with * * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$
(Source: calculations based on data from own household survey, 2012)

Table 9. Estimated effects of membership in cooperatives with individual remuneration, collective remuneration or saved revenues on farm performance

	Cooperatives with individual payment		Cooperatives with collective payment		Cooperatives with saved revenues	
Dependent variables	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
log (farm income)	0.23	0.17	0.06	0.08	0.32*	0.37**
	(0.20)	(0.24)	(0.18)	(0.19)	(0.18)	(0.18)
log (farm income/worker)	0.23	0.16	-0.006	0.008	0.27	0.31*
	(0.20)	(0.24)	(0.18)	(0.19)	(0.18)	(0.18)
log (gross farm revenue)	0.52***	0.42**	0.21	0.19	0.35**	0.37**
	(0.16)	(0.19)	(0.16)	(0.16)	(0.16)	(0.17)
Share of farm produce sold	0.27***	0.19***	0.08**	0.07*	0.09**	0.07**
	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
Value of inputs used (RWF)	17,409***	12,051*	2,311	2,250	4,922***	3,963**
	(5,298)	(6,308)	(1,610)	(1,653)	(1,688)	(1,728)
Use of improved seeds (dummy)	0.44***	0.38***	0.08	0.08	0.29***	0.28***
	(0.07)	(0.09)	(0.08)	(0.08)	(0.07)	(0.07)
Use of mineral fertilizer (dummy)	0.48***	0.45***	0.006	-0.004	0.29***	0.30***
	(0.06)	(0.07)	(0.08)	(0.08)	(0.07)	(0.07)
Use of pesticides (dummy)	0.36***	0.35***	0.08	0.09	0.16***	0.16***
	(0.06)	(0.07)	(0.05)	(0.06)	(0.06)	(0.06)
Use of irrigation (dummy)	0.46***	0.42***	0.08	0.04	0.30***	0.31***
	(0.05)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)

Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP).
For model 1 and 2, Estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables.
Standard errors are shown in parentheses. Significant effects are indicated with * * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$.
(Source: calculations based on data from own household survey, 2012)

The findings from Table 8 and 9 imply that the way cooperatives arrange production and marketing is more important in explaining differences in performance across cooperatives than crop and market characteristics. Our results are in line with an incentive-compatibility explanation. We find the largest effects of cooperative membership on farm performance for cooperatives in which farmers' incentives are least distorted, i.e. in cooperatives where production and remuneration is individually-based while land acquisition and marketing are done jointly.

7. Conclusion

In this paper, we analyze the effect of membership in agricultural cooperatives on the performance of smallholder farms in Rwanda. We find that cooperative membership leads to the adoption of modern inputs, increased intensification, increased commercialization of farm produce, and higher revenue, labor productivity and farm income. These results support the idea that agricultural cooperatives can be an important institution to promote the transformation of the smallholder farm sector from a (semi-) subsistence farm sector to a commercial and intensified agricultural sector.

We explicitly look at maize and horticulture cooperatives and find there is a large diversity in how cooperatives are organized. This diversity in cooperatives translates into heterogeneity in the impact of cooperative membership on farm performance. Maize cooperatives are found to perform better and to bring about more benefits for their members than horticulture cooperatives. Yet, this heterogeneity in effects between maize and horticulture cooperatives can be explained by differences in the way cooperatives organize production, through individual or communal labor, and in the way members are remunerated, individually or collectively. We find the largest effects of cooperative membership on farm performance for cooperatives in which farmers' incentives are least distorted, i.e. in cooperatives where production and remuneration is individually-based while land acquisition and marketing are done jointly. Also differences in crop and market characteristics may contribute to explaining observed differences in effects but our findings do not support the point of view that cooperatives create the largest benefits for higher value crops.

Our results imply that the foundation of cooperatives in lower value staple food sectors as well as in higher value horticulture sectors, can contribute to the modernization of the smallholder farm sector and improve farmers' income. However, cooperatives should refrain

from organizing agricultural production in a communal way – even on cooperatively acquired land – and from implementing collective payment systems. They should focus on cooperative marketing and cooperative input supply and land acquisition, with remuneration systems that are in line with individual farm-household incentives. Collective action is sometimes indicated as a prerequisite for cooperatives to be successful – likely as a reaction on the failure of government-controlled agricultural cooperatives in centrally-planned economic systems. However, we do not find evidence of this argument as government-initiated cooperatives in Rwanda do not perform worse than cooperatives that are initiated through collective action – as long as they function in a way that is compatible with famers' individual incentives.

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Annex 1: Full regression results

Table A1.1. Estimated effects of membership in maize cooperatives on farm performance (full regression results)

Outcome variable	log (farm income)		Share of farm produce sold		Value of inputs used (RWF)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
HH coop.member (dummy)	0.68***	0.62***	0.20***	0.17***	12.670***	9.246*
	(0.18)	(0.20)	(0.037)	(0.041)	(4.723)	(5.268)
Female single HH	-0.24	-0.22	-0.080*	-0.072*	-6.526	-5.517
	(0.30)	(0.20)	(0.042)	(0.042)	(5.423)	(5.455)
HH head age (yrs)	0.052	0.054	-0.0058	-0.0047	-123	6
	(0.037)	(0.037)	(0.0077)	(0.0077)	(989)	(991)
Square of HH head age	-0.0003	-0.0004	0.00	0.00	-1.76	-2.8
	(0.0004)	(0.0004)	(0.0001)	(0.0001)	(9.76)	(9.76)
HH head education (yrs)	0.056**	0.054**	0.0029	0.0021	484	384.38
	(0.024)	(0.024)	(0.005)	(0.005)	(642)	(645)
HH agricultural workers (#)	0.052	0.052	-0.0009	-0.0007	3.231*	3.255*
	(0.070)	(0.0703)	(0.015)	(0.015)	(1.941)	(1.937)
HH children (#)	0.0079	0.0093	-0.0035	-0.003	-1.646	-1.582
	(0.043)	(0.043)	(0.0091)	(0.009)	(1.171)	(1.169)
Land owned (ha)	0.013***	0.013***	0.0004	0.0003	62	48
	(0.0028)	(0.0028)	(0.0006)	(0.0006)	(77)	(78)
Square of land owned	-0.00***	-0.00***	0.00	0.00	-0.082	-0.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.18)	(0.18)
TLU	0.10	0.11	0.0097	0.011	5.953***	6.122***
	(0.067)	(0.067)	(0.014)	(0.014)	(1.816)	(1.816)
Distance to the market (min)	0.0033	0.0032	0.0003	0.0002	-27	-30
	(0.0026)	(0.0027)	(0.0006)	(0.0006)	(72)	(71)
Siblings close by (#)	0.072**	0.071**	-0.0002	-0.0006	-427	-475
	(0.032)	(0.032)	(0.0068)	(0.0068)	(876)	(874)
log (WTP)		0.020		0.0097*		1.179*
		(0.030)		(0.0063)		(811)
_cons	10***	9.8***	0.40	0.22	10.400	-11.391
	(1.3)	(1.3)	(0.24)	(0.23)	(31.352)	(29.918)
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.4317	0.4328	0.3426	0.3490	0.2449	0.2515

Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP). For model 1 and 2, estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 271, of which 133 maize cooperative member and 138 control households.

Table A1.2. Estimated effects of membership in horticulture cooperatives on farm performance (full regression results)

Outcome variable	log (farm income)		Share of farm produce sold		Value of inputs used (RWF)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
HH coop.member (dummy)	0.026	0.039	0.12***	0.093***	4.419***	3.693**
	(0.17)	(0.18)	(0.033)	(0.034)	(1.486)	(1.569)
Female single HH	-0.36*	-0.37*	-0.019	-0.0082	-1.831	-1.499
	(0.20)	(0.20)	(0.039)	(0.039)	(1.749)	(1.761)
HH head age (yrs)	0.079*	0.079*	-0.0013	-0.0012	-292	-290
	(0.042)	(0.042)	(0.008)	(0.0079)	(362)	(361)
Square of HH head age	-0.0006	-0.0006	0.00	0.00	1.74	1.80
	(0.0004)	(0.0004)	(0.0001)	(0.0001)	(3.66)	(3.65)
HH head education (yrs)	0.047**	0.048**	0.0077*	0.0065	551***	515**
	(0.023)	(0.023)	(0.0044)	(0.0044)	(201)	(202)
HH agricultural workers (#)	0.097	0.098	-0.012	-0.013	233	195
	(0.090)	(0.090)	(0.017)	(0.017)	(789)	(787)
HH children (#)	-0.036	-0.037	-0.020**	-0.018**	194	231
	(0.049)	(0.049)	(0.0093)	(0.0093)	(423)	(424)
Land owned (ha)	0.013***	0.013***	0.0010*	0.0009	37	33
	(0.0031)	(0.0031)	(0.0006)	(0.0006)	(28)	(28)
Square of land owned	-0.00***	-0.00***	0.00	0.00	-0.055	-0.040
	(0. 00)	(0.00)	(0.00)	(0.00)	(0.072)	(0.072)
TLU	0.26***	0.26***	0.0032	0.0027	928	913
	(0.083)	(0.083)	(0.0159)	(0.016)	(722)	(721)
Distance to the market (min)	0.0011	0.001	-0.0009	-0.0009	56**	58**
	(0.0029)	(0.0029)	(0.0006)	(0.0006)	(25)	(25)
Siblings close by (#)	0.032	0.032	0.0037	0.0032	141	126
	(0.035)	(0.035)	(0.0067)	(0.0066)	(302)	(301)
log (WTP)		-0.0068		0.012**		354
		(0.029)		(0.0055)		(249)
_cons	9.4***	9.5***	0.31	0.23	8.260	5812
	1.5	1.5	0.28	0.28	12.811	12.899
Prob > F	0.00	0.00	0.00	0.00	0.0001	0.0001
R-squared	0.4087	0.4088	0.2782	0.2924	0.2447	0.2514

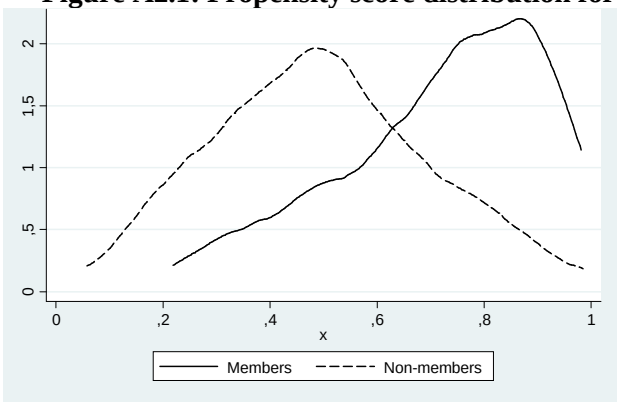
Notes: The different estimation methods are referred to as model 1 (OLS regression on X), model 2 (OLS regression on X and WTP). For model 1 and 2, estimated coefficients are reported for continuous outcome variables and marginal effects for binary outcome variables. Standard errors are shown in parentheses. Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 256, of which 118 horticulture cooperative member and 138 control households

(Source: calculations based on data from own household survey, 2012)

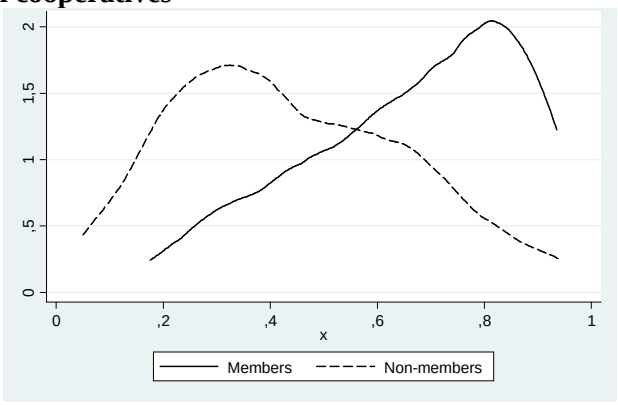
Annex 2: Robustness checks for PSM estimations

Overlap and distribution of estimated propensity scores

Figure A2.1: Propensity score distribution for all cooperatives

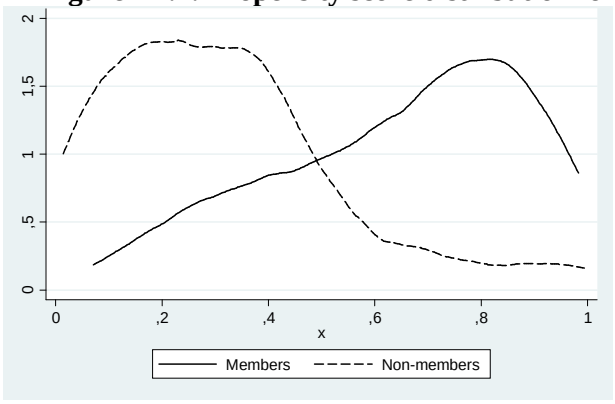


a. Kernel density plot, model 3

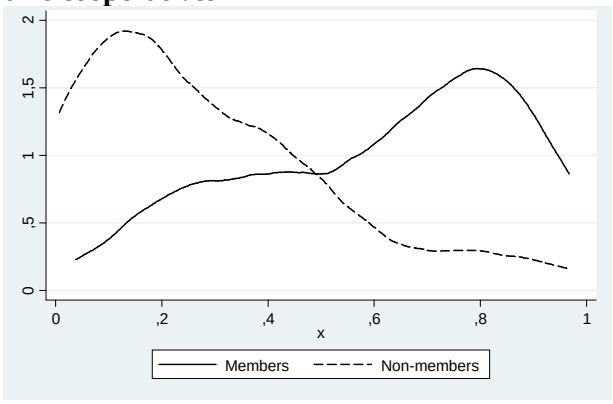


b. Kernel density plot, model 4

Figure A2.2: Propensity score distribution for maize cooperatives

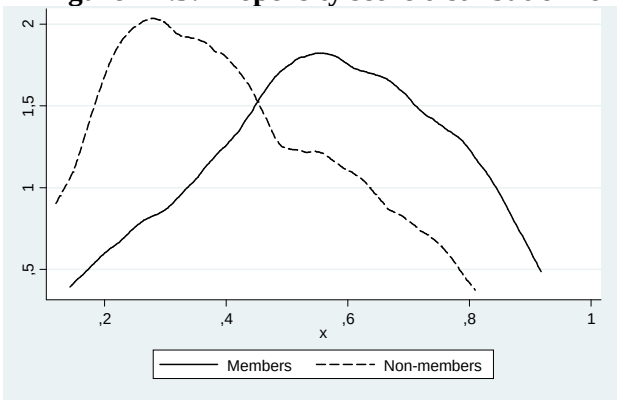


a. Kernel density plot, model 3

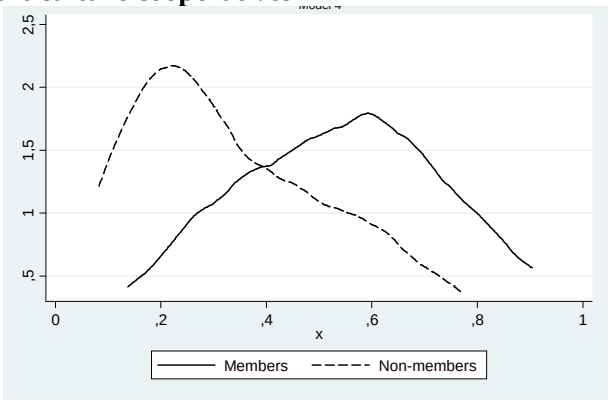


b. Kernel density plot, model 4

Figure A2.3: Propensity score distribution for horticulture cooperatives



a. Kernel density plot, model 3



b. Kernel density plot, model 4

Balancing properties

Table A2.1. Balancing properties of covariates in member and non-member (control) households for kernel matching on propensity scores

Model		Mean bias	Median bias	Pseudo-R^2	LR
Total sample[a] - Model 3	Unmatched	30.7	18.8	0.200	99.86***
	Matched	7.1	3.8	0.013	8.65
Total sample[a] - Model 4	Unmatched	33.2	24.4	0.292	146.04***
	Matched	3.3	2.8	0.007	3.37
Maize cooperatives[b] - Model 3	Unmatched	33.8	20.5	0.288	83.56***
	Matched	12.6	10.4	0.058	18.83
Maize cooperatives[b] - Model 4	Unmatched	36.3	25.7	0.392	145.09***
	Matched	12.3	10.0	0.053	13.73
Horticulture cooperatives[c] - Model 3	Unmatched	28.4	35.5	0.178	62.00***
	Matched	5.1	4.1	0.009	2.60
Horticulture cooperatives[c] - Model 4	Unmatched	30.3	35.9	0.241	84.25***
	Matched	5.3	5.4	0.019	4.98

The different estimation methods are referred to as model 3 (PSM with X as conditioning factors) and model 4 (PSM with X and WTP as conditioning factors).

[a] Total number of observations is 389, of which 251 cooperative member and 138 control households.

[b] Total number of observations is 271, of which 133 maize cooperative member and 138 control households

[c] Total number of observations is 256, of which 118 horticulture cooperative member and 138 control households

Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$

(Source: calculations based on data from own household survey, 2012)

First stage probit estimation results

Table A2.2. First stage probit estimation: probability of cooperative membership (marginal effects)

Outcome variable	All members[a]				Maize cooperative members[b]				Horticulture cooperative members[c]			
	Model 3		Model 4		Model 3		Model 4		Model 3		Model 4	
Female single HH	0.139	**	0.154	***	0.053		0.085		0.232	***	0.225	***
	(0.058)		(0.054)		(0.073)		(0.064)		(0.070)		(0.067)	
HH head age (yrs)	0.024	**	0.017		0.021		0.013		0.027	*	0.021	
	(0.011)		(0.011)		(0.013)		(0.012)		(0.015)		(0.015)	
Square of HH head age	0.000		0.000		0.000		0.000		0.000		0.000	
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
HH head education (yrs)	0.018	***	0.008		0.027	***	0.014	*	0.012		0.005	
	(0.007)		(0.006)		(0.008)		(0.008)		(0.008)		(0.008)	
HH agricultural workers (#)	0.090	***	0.081	***	0.106	***	0.083	***	0.093	***	0.088	***
	(0.024)		(0.023)		(0.026)		(0.024)		(0.033)		(0.031)	
HH children (#)	-0.024	*	-0.022		-0.042	**	-0.030	**	-0.015		-0.018	
	(0.014)		(0.013)		(0.016)		(0.015)		(0.018)		(0.017)	
Land owned (ha)	0.000		0.001		-0.001		-0.001		0.002		0.002	
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
Square of land owned	0.000		0.000		0.000		0.000		0.000		0.000	
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
TLU	0.123	***	0.102	***	0.155	***	0.119	***	0.105	***	0.096	***
	(0.021)		(0.020)		(0.023)		(0.021)		(0.028)		(0.027)	
Distance to the market (min)	-0.001	**	-0.001	*	-0.002	**	-0.002	*	-0.001		-0.001	
	(0.001		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
Siblings close by (#)	0.008		0.008		0.015		0.013		0.004		0.004	
	(0.010)		(0.009)		(0.012)		(0.011)		(0.013)		(0.012)	
log (WTP)			0.000	***			0.000	***			0.000	***
			(0.000)				(0.000)				(0.000)	
Prob > F	98.99		142.95		99.49		148.74		59.63		81.77	
R2	0.20		0.28		0.26		0.39		0.17		0.23	
N	389		389		271		271		256		256	

Notes: The different estimation methods are referred to as model 3 (PSM with X as conditioning factors) and model 4 (PSM with X and WTP as conditioning factors).

[a] Total number of observations is 389, of which 251 cooperative member and 138 control households.

[b] Total number of observations is 271, of which 133 maize cooperative member and 138 control households

[c] Total number of observations is 256, of which 118 horticulture cooperative member and 138 control households

Significant effects are indicated with *; * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$, Standard errors are shown in parentheses.

(Source: calculations based on data from own household survey, 2012)

Conditional independence

Table A2.3. Simulation-based sensitivity analysis

	Neutral Confounder			Confounder calibrated to mimic dummy for female headed households		
Dependent variables	Estimator effect[a]	Outcome effect[b]	Selection effect[c]	Estimator effect[a]	Outcome effect[b]	Selection effect[c]
Maize cooperatives[d]						
log (farm income)	-1.2%	1.18	1.15	-1.2%	1.477	1.078
log (farm income/worker)	-1.4%	1.22	1.06	6.8%	1.271	1.208
log (gross farm revenue)	-1.4%	1.04	1.03	-1.4%	1.069	0.984
share of farm produce sold	0.6%	1.02	1.09	0.0%	0.292	1.195
Value of inputs used (RWF)	0.8%	1.16	1.09	-0.5%	0.367	1.310
Use of improved seeds (dummy)	0.3%	1.23	0.94	-1.2%	1.447	1.003
Use of mineral fertilizer (dummy)	-2.8%	1.12	1.09	0.5%	1.234	1.091
Use of pesticides (dummy)	1.6%	1.13	1.01	0.0%	0.968	0.986
Use of irrigation (dummy)	0.7%	1.22	1.08	0.5%	0.808	1.007
Horticulture cooperatives[e]						
log (farm income)	-3.0%	1.248	1.06	-5.9%	1.117	2.258
log (farm income/worker)	-1.2%	1.21	1.08	1.2%	1.206	2.243
log (gross farm revenue)	2.7%	1.11	1.14	-5.4%	1.212	2.252
share of farm produce sold	2.3%	1.10	1.02	-15.9%	0.308	2.260
Value of inputs used (RWF)	-0.2%	1.07	0.96	-5.4%	0.466	1.983
Use of improved seeds (dummy)	-0.3%	1.09	1.10	7.6%	1.655	2.135
Use of mineral fertilizer (dummy)	-2.7%	1.15	1.06	12.3%	1.011	2.172
Use of pesticides (dummy)	-3.5%	1.27	1.05	8.7%	0.995	2.180
Use of irrigation (dummy)	0.4%	1.15	1.01	0.0%	0.793	1.942

[a] The estimator effect indicates to what extend the baseline estimation result would change if we could observe an additional binary confounder

[b] The outcome effect measures the estimated effect of the simulated binary confounder on the dependent

[c] The selection effect measures the estimated effect of the simulated binary confounder on the selection into treatment, this is the propensity of being a member in a maize and horticulture cooperative, respectively.

[d] Total number of observations is 271, of which 133 maize cooperative member and 138 control households

[e] Total number of observations is 256, of which 118 horticulture cooperative member and 138 controls

(Source: calculations based on data from own household survey, 2012)

To test the robustness of our matching estimators to failure of the conditional independence assumption, we perform a simulation-based sensitivity analysis, as proposed by Ichino et al. (2008) and recently used by Ito et al. (2012) and Maertens et al. (2011). The results of these analyses are presented in table A2.3. Suppose that the conditional independence assumption is not satisfied given the observable covariates included in the analysis but that it would be satisfied if we would be able to observe one additional binary variable. The idea behind the method is to simulate a potential confounder in the data and use it as an additional covariate in the PSM. A comparison of the estimates obtained with and without the simulated confounder gives an indication of the extent to which the baseline estimation results are robust to specific sources of violation of the conditional independence assumption (Nannicini, 2007). We use a neutral confounder and a confounder calibrated to mimic the observable binary covariate female-headed household, as additional matching factors. The results indicate that the estimates with binary confounder differ less than 13% from the baseline matching estimators which indicates robust estimates.

Chapter 5

Heterogeneous impact of cooperative membership on farmers' welfare in Rwanda

1. Introduction

Improving the productivity, profitability and sustainability of smallholder agriculture is argued to be the main pathway out of rural poverty in developing countries (Hazell et al., 2010; World Bank, 2008). Institutional innovations are believed to play a crucial role in this as they can help farmers to overcome market failures (Hazell et al., 2010; Thomas and Slater, 2006; World Bank, 2008). There is a renewed interest in producer organizations such as cooperatives as an institutional tool to improve market participation of smallholder farmers, increase farm incomes and reduce rural poverty (Bernard and Spielman, 2009; Bernard and Taffesse, 2012; Fisher and Qaim, 2012a; 2012b; Markelova et al., 2009; Shiferaw et al., 2009). To have an effect on poverty, these emerging institutions need to be both, inclusive – i.e. poorer farmers need to participate – and effective – i.e. creating an impact on farmers' income and wellbeing. Cooperatives are often associated with collective action and social capital, and are therefore regularly thought to be more inclusive than other types of institutional innovations such as contract farming[1].

Various empirical studies have verified how inclusive cooperatives are, and investigated which farmers are included in (or excluded from) cooperatives. In general, participation in cooperatives is found to be closely linked to human and social capital (Hellin et al., 2009). More particularly, farmers' level of education, farmers' age and farming experience are found to have a positive (but sometimes decreasing) effect on the likelihood of cooperative membership (e.g. Bernard and Spielman, 2009; Fischer and Qaim, 2012a; Francesconi and Heerinck, 2010; Ito et al., 2012). Access to social networks and information, as well as

[1] Contract farming is a widely studied institutional innovation, both from the perspective of inclusion and of effectiveness. While some studies question the beneficial impact of contract farming (e.g. Eaton and Shepherd, 2001; Dolan, 2001; Singh, 2003), there is a growing amount of recent evidence that contract farming has a positive effect on farm performance and farmers' welfare (e.g. Bellemare, 2012; Dedehouanou et al., 2013; Maertens and Swinnen, 2009a; Minten et al., 2009; Rao and Qaim, 2011). Yet, contract farming is often found to be exclusive; most studies point out that contracts are biased towards better-off farmers while the poorest farmers are excluded (e.g. Maertens and Swinnen, 2009a; Neven et al., 2009; Rao et al., 2012).

physical capital and farmers' asset endowments matter too (e.g. Fischer and Qaim, 2012a; Markelova and Mwangi, 2009; Matuschke and Qaim, 2009; Okello et al., 2007). For example, land and livestock holdings are found to have a positive (but sometimes decreasing) effect on the likelihood of farmers to participate in cooperatives (e.g. Bernard and Spielman, 2009; Fischer and Qaim, 2012a; Ito et al., 2012). Some studies conclude that the poorest farmers are excluded (e.g. Fischer and Qaim, 2012a; Francesconi and Heerinck, 2010; Ito et al., 2012; Quisumbing et al., 2008) while others point to a middle-class effect with both the poorest and the most wealthy farmers least likely to participate (Bernard and Spielman, 2009). The prevailing evidence suggests that cooperatives are exclusive to some extent.

Concerning the effectiveness of cooperatives to bring about output growth and improved wellbeing, there is a growing amount of recent evidence that cooperatives positively affect farm performance and market participation. More specifically, participation in cooperatives is found to positively affect producer prices and to improve market access and participation (e.g. Abebaw and Haile, 2013; Bernard et al., 2008; Bernard and Taffesse, 2012; Fisher and Qaim, 2012a; Francesconi and Heerink, 2010; Holloway et al., 2000; Ito et al., 2012; Shiferaw et al., 2009; Wollni and Zeller, 2007). Also the likelihood of adopting improved technologies, such as mineral fertilizer, is found to be positively affected by cooperative membership (e.g. Abebaw and Haile, 2013; Francesconi and Heerink, 2010; Shiferaw et al., 2009). Other studies point to a positive impact on farm incomes and profits (e.g. Fisher and Qaim, 2012a; Ito et al., 2012; Vandeplas et al., 2013). Yet, the poverty effects of cooperatives have rarely been analyzed.

As the overall poverty impact of institutions and programs hinges on both inclusion and effectiveness, it is important to look beyond mean treatment effects. Only a handful of studies have specifically analyzed how the effect of cooperative membership on farm performance and farmer wellbeing changes with farm and farmer characteristics. Bernard et al. (2008) find that cooperative membership leads to a higher degree of commercialization for cereal farmers in Ethiopia; but the effect is larger for the largest farms and even negative for very small farms. Ito et al. (2012) find that the impact of cooperative membership on farm income for watermelon farmers in China is twice as large for small farms than for larger farms. Fisher and Qaim (2012a) find that the effects of participating in banana cooperatives in Kenya on commercialization, technology adoption and farm income are more pronounced for the smallest farms. Abebaw and Haile (2013) study the impact of cooperative membership on the likelihood of fertilizer adoption among farmers in Ethiopia and find that there is a stronger

positive effect for less educated farmers and an inverse U-shaped effect of distance to the market.

In this paper we look at membership of smallholder farmers in land and marketing cooperatives in Rwanda and analyze the impact of this membership on household income and poverty. We look at mean income and poverty effects as well as at heterogeneous treatment effects across farmers. We use several propensity score matching techniques to estimate the average treatment effect of cooperative membership on farm income, total household income and the likelihood of being poor. We then analyze how the estimated treatment effect varies with various farm and farmer characteristics and with the estimated propensity score. We find that the membership of land and marketing cooperatives in general has a positive impact on income and a negative impact on the likelihood of being poor but that the effect varies with farm size, distance to the market, and the availability of labor in the household.

Our focus on Rwanda is particularly relevant because cooperatives are very important in the country. Agricultural cooperatives are seen as an important institutional vehicle to improve the performance of the smallholder farm sector and to achieve rural poverty reduction (GoR, 2004; 2011). A handful of qualitative studies has pointed out that cooperatives in Rwanda are to some extent exclusive and aggravate existing inequalities in rural communities (Ansoms, 2009; 2010; Nabahungu and Visser, 2011; Pritchard, 2013). Farmers perceive cooperative membership to depend on their financial capital, their labor endowments, their social connections and access to information, and to result in reinforcement of existing power imbalances (Ansoms, 2010). Mujawamariya et al. (2013) point out that trust in the cooperative management is a crucial issue for participation and that some benefits of cooperatives may trickle down to nearby non-member farmers. There are however very few studies that analyze the impact of cooperative membership on rural incomes and poverty reduction in a quantitative way. Yet, quantitative evidence on both, the inclusiveness and the effectiveness of cooperatives can complement these qualitative insights.

Our approach to look at heterogeneous treatment effects allows analyzing both inclusion and effectiveness of cooperatives in a comprehensive way. Examining heterogeneity in treatment effects stems from the program evaluation literature. The evaluation of development programs (e.g. Behrman and Hoddinott, 2005; Lechner, 2002; Millimet and Tchernis, 2013) and public health programs (e.g. Arnstein and Arpino, 2007; Basu et al., 2007) has moved beyond mean impact studies into studies analyzing the distribution of impacts within the

treated subjects. Such heterogeneous treatment effect studies are important from the perspective of program targeting. If a treatment, which is often costly and/or related to complex management, is available only for those who are most likely to benefit from it, increasing the group of treated subjects can reduce the average effectiveness of the treatment. However, if the group of participants is actually not composed of the subjects who are the most likely to benefit, increasing the participant group or retargeting the program will probably increase the average treatment effect (Xie et al., 2012). Thus, analyzing how the treatment effect varies within the population can increase the efficiency of program targeting by assigning eligibility to those subjects that benefit most from the participation (Djebbari and Smith, 2008). Estimating heterogeneous treatment effects of cooperative membership can reveal whether a positive or a negative selection hypothesis applies (Brand and Xie, 2013; Xie et al., 2010). There is negative selection if subjects with the lowest probability to be treated, benefit most from treatment while a positive selection implies that subjects, for whom the benefit from treatment is largest, are also most likely to be treated (Brand and Xie, 2013). Such insights are important to understand whether and how cooperatives can be more pro-poor.

2. Background and data collection

In Rwanda, the agricultural sector is a key engine for economic development and poverty reduction, contributing 34% to GDP and about 90% to employment in 2012 (GoR, 2011; World Bank, 2012). Rwandan agricultural policies and strategies focus on intensification of agricultural production and increased market orientation with an important role for cooperatives as vehicle to spur the modernization of the smallholder agricultural sector (GoR, 2011). The national land policy has played a role in the establishment of cooperatives and the number of agricultural cooperatives in the country has expanded very rapidly during the past couple of years (USAID, 2013). In 2004, the national land use policy ordered for the founding of cooperatives for the cultivation of marshlands and for land consolidation projects to avoid parceling of this valuable agricultural land (GoR, 2004). The regulation designates these areas as a special category of public, thus state-owned, land with usufruct rights in the form of concessions and with the allocation responsibility within the Ministry of Lands and Environment. Cultivation of the marshlands is regulated by the government and only accessible for official cooperatives (GoR, 2004). Besides access to productive marshland areas, cooperatives also play a role in distributing subsidized inputs, especially mineral

fertilizer (World Bank, 2010). In this study we focus the Muhanga district in the Southern province of Rwanda, where we mainly find maize and horticultural cooperatives.

We use original household survey data collected between February and March 2012. A three-stage stratified random sampling technique was used. Based on secondary data and meetings with local government officials and cooperative support organizations, 26 active cooperatives in the district were identified. In the first stage, we randomly selected cooperatives from three different strata: 7 out of 12 cooperatives only selling at local wet markets and the urban market in Muhanga (the provincial capital), 5 out of 10 cooperatives also selling to traders from more distant markets, and all 4 cooperatives with experience in selling to processing companies and exporters. In the second stage, we randomly selected 40 villages (*imidugudu*) of the 61 villages where the 16 cooperatives are active. In the third stage, we stratified households in these villages according to cooperative membership, and selected 251 cooperative member households, belonging to 16 cooperatives, and 138 control households. Cooperative members were oversampled because of our specific interest in the different cooperatives[2].

There is a large diversity between the cooperatives in the sample, with cooperatives specialized in maize, cooperatives specialized in horticulture produce, and cooperatives engaging in both these sectors. The degree of cooperative organization differs strongly across the cooperatives. Some cooperatives organize the acquisition of agricultural land jointly and engage in cooperative marketing of produce while the cultivation on cooperatively acquired land is done on an individual basis with farmers cultivating an allocated part of the cooperative land. Other cooperatives organize agricultural production on cooperative land in a communal way. Previous research has shown that the latter types of cooperatives do not have an impact on the performance of member farmers because the way they function is not compatible with farmers' incentives (Verhofstadt and Maertens, 2013). Therefore, we restrict the analysis in this paper to the former types of cooperatives, which we broadly define as 'land and marketing cooperatives'. We refer to households who are member of these land and marketing cooperatives as cooperative member households or treated households; and to households who are not a member of these land and marketing cooperatives, whether or not they belong to other types of cooperatives, as non-member households or control households.

[2] As the sampling stratification method led to oversampling of cooperative member households, we correct for this sampling bias by using sample weights in the descriptive analyses. While the estimated proportion of cooperative member households in the sample is 65%, the estimated proportion in the population is about 28.8%.

The analysis in this paper is hence based on observations of 389 farm households, including 154 cooperative member households and 235 control households.

The household survey instrument, a quantitative structured questionnaire, provides data on household demographic characteristics, land and non-asset holdings, agricultural production, off-farm employment, non-labor income, cooperative membership, savings and credit; and allows calculating household total income and income from farming. The household survey data were complemented with data from interviews with the different cooperatives. This contains data on cooperative activities, investments, credit, sourcing and marketing strategies, and organizational set-up.

3. Econometric approach

3.1. Selection bias in cooperative membership

If cooperative membership would be randomly distributed across households in the population, we could evaluate the causal effect of cooperative membership on households' welfare outcomes as the difference in average outcome between member and non-member households. Yet, the literature provides sufficient evidence to expect that there is a selection bias in cooperative membership and that participation in a cooperative is influenced by some of the same household characteristics that influence welfare. Thus, in order for our results to be valid and to reveal the underlying causal effect of cooperative membership on the welfare outcomes, we consider the selection bias as a sample selection problem and, based on the counterfactual framework of Rosenbaum and Rubin (1983), calculate average treatment effects (ATE) (Ichino, 2008).

We want to compare the welfare outcomes for cooperative member or treated households with non-member or control households that are similar in terms of observable characteristics (Angrist and Imbens; 1996; Caliendo and Kopeinig, 2008; Imbens, 2004). However, if multiple conditioning factors – the variables for which we want the treated and control households to be comparable – are used, matching a treated with a control household becomes difficult due to the dimensionality of the conditioning problem. Therefore we estimate the propensity score (PS) as the probability of being a cooperative member, and compare households with the same probability of being member in the cooperative (Rosenbaum and Rubin, 1983). In this way, matching according to the PS results in the comparison of cooperative member or treated households with non-member or control households that are

similar in terms of observable characteristics (Caliendo and Kopeinig, 2008; Imbens, 2004; Imbens and Angrist, 1995).

The propensity score is estimated as the probability of being member of a cooperative (D), using different conditioning factors (X) to control for a possible non-random distribution of cooperative membership in the population:

$$PS = P(D=1|X) \quad (1)$$

The variables included in X relate to household demographic characteristics, household asset ownership, a social capital indicator and a market access indicator – as described in Table 1. As the resulting PS can be considered as the probability of being a cooperative member, the results from the probit model used for calculating the PS can give valuable insights on whether cooperative membership is biased towards certain types of households and hence on the inclusiveness of the cooperatives. These results will be discussed in Section 4.2

Table 1. Conditioning factors used as covariates in the probit model to calculate the PS

Variable	Description
Demographic characteristics	
Female single HH	Dummy for single, female-headed households
HH head age (yrs)	Age of the household head in years
Square of HH head age	
HH head education (yrs)	Years of education of the household head
HH agricultural workers (#)	Number of agricultural workers in the household
HH children (#)	Number of children (age < 18 years) in the household
Asset ownership	
Land owned (ha)	The total area owned by the household, expressed in hectares
Square of land owned	
TLU	The number of tropical livestock units (TLU) possessed by the household
Social capital	
Siblings close by (#)	The number of brothers and sisters of the household head and his/her partner living close by
Market access	
Distance to the market (min)	The mean distance to the market, expressed in minutes of walking distance, of the plots under cultivation

3.2. Treatment effects of cooperative membership

We calculate average treatment effects (ATE) of cooperative membership on four different outcome variables: farm income, total household income, total household income per adult equivalent, and the likelihood of being poor. We estimate the treatment effects by matching according to the PS and calculating the ATE as the average outcome differences between treated Y(1) and matched controls Y(0) (Dehejia and Wahba, 2002; Imbens, 2004):

$$ATE = E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)] \quad (2)$$

Matching is done with replacement to assure that each treatment unit is matched to the control unit with the closest PS, which reduces bias (Dehejia and Wahba, 2002).
As PS matching methods are sensitive to the exact specification and matching method, we use different PS matching techniques as additional robustness checks: nearest neighbor matching with one neighbor, nearest neighbor matching with three neighbors, kernel matching and a local linear matching. With a single-nearest neighbor matching every treated household is matched to the control household with the closest PS and the average treatment effects on the outcome variables are calculated by averaging the differences in outcomes between the treated and matched control households. This matching technique, however, can result in poor matches because the treated and the closest control unit still can have large differences in their PS but will still contribute to the calculation of the average treatment effect (Imbens, 2004). We further choose to use more than one nearest neighbor (3). In this case the average treatment effect is calculated by averaging the differences in outcomes between the treated household and the average outcome of the 3 matched control households with the closest PS. Using more information to construct the counter-factual outcome will result in a reduced variance but the bias might increase in case of poorer matching (Caliendo and Kopeinig, 2004).

The advantage to also apply kernel and local linear matching lies in the fact that, contrary to the previous methods in which only a few observations from the control group are used, these matching estimators use weighted averages of all individuals in the control group to construct the counterfactual outcome of treated observations. We apply kernel matching, using the default Gaussian kernel, and match treated units (cooperative members) to a construct of matched control cases which is obtained as the weighted average of nearest control units (non-members) with weights depending on the PS distance between treated and control units, thus persons closer by a treated individual (in terms of PS) will get a higher weight. Kernel matching can be considered as a regression on a constant term while local linear matching uses a constant and a slope term, thus it includes a linear term in the weighting function. This helps to avoid bias when comparison group observations are distributed asymmetrically around treated observations or when there are gaps in the propensity score distribution (Caliendo and Kopeinig, 2004).

The reliability of PS matching estimators depends on two crucial assumptions. First, the common support or overlap condition requires balancing in the covariate distribution between treated and untreated observations to ensure that treatment observations have comparison

control observations nearby in the PS distribution (Caliendo and Kopeinig, 2008). As proposed by Heckman et al. (1997) and Becker and Ichino (2002), we only use observations in the common support region in the analysis, this is the region where the PS of the control units is not smaller than the minimum PS of the treated units and the PS of the treated units not larger than the maximum PS of the control units (Becker and Ichino, 2002). Second, the conditional independence assumption states that that given a set of observable covariates, potential outcomes are independent of treatment assignment (Imbens, 2004). This implies that selection into treatment is based entirely on observable covariates, which is a strong assumption. We test the robustness of our matching estimators to failure of the conditional independence assumption by performing a simulation-based sensitivity analysis (Ichino et al., 2008; Ito et al., 2012; Maertens et al., 2011). The results of the balancing properties, a visual inspection of the overlap condition and the simulation based sensitivity analysis for the kernel matching will be shortly discussed in Section 5.2.

3.3. Heterogeneity in treatment effects

Within the group of cooperative members the impact of cooperative membership may vary with farm and farmer characteristics. We analyze this impact heterogeneity of cooperative membership on our four outcome variables.

Different methods have been used in the literature to study heterogeneous effects of cooperative membership. The most common method is to compare treatment effects across subsamples with different characteristics. For example, Ito et al. (2012) and Fischer and Qaim (2012a) study the heterogeneity in treatment effects by disaggregating the farmer households by farm sizes. Mutuc et al. (2013) apply a treatment effect analysis by aggregating treatment effects to propensity score group-level mean effects and observe whether different trends in effects occur. In their study on the impact of cereal cooperatives in Ethiopia on the commercialization behavior of smallholders, Bernard et al. (2008) graphically examine heterogeneous effects of cooperative membership by plotting the distribution of the cooperative's impact on members' percentage of production sold and interact the treatment dummy variable with household level variables in a linear regression analysis.

We apply the method as proposed by Abebaw and Haile (2013). They calculate the average treatments effects in the treated households and then use a linear regression model in which the household level treatment effect of cooperative membership on the outcome variable of interest is used as the dependent variable and is evaluated on some background

characteristics of the cooperative member households. This method has the advantage over methods looking at subsamples because looking at the whole distribution of the treatment effect can reveal non-linearities. For a visual inspection, we – inspired by the work of Mutuc et al. (2013) – plot the treatment effects, generated using the kernel matching method, over the range of the background characteristics and derive a smoothed curve. We graphically and statistically examine how the household level treatment effects vary with the following farm and farmer characteristics: the age, education and gender of the household head, the agricultural labor force in the household, the size of the household's owned plots and the distance to the market. Additionally we investigate how the impact of cooperative membership changes with the propensity of being a cooperative member.

4. Inclusiveness of cooperatives

4.1. Comparison of members and non-members

In Table 2 we compare cooperative member or treated households with non-member or control households. Cooperative member households have a relatively older household head and more agricultural labor force in the household. Further, we see that non-member households are significantly more often headed by a single woman. In general 22% of the households in the population are single female-headed households; which is in line with the 27.7% single female headed households in the Muhanga district reported by the recent national EICV results (NISR, 2012). There are no significant differences in the education of the household head, the number of children in the household, the distance to the market and the number of siblings close by. With regard to the farm characteristics, we find that land- and livestock holdings in general are quite small. On average households own 0.27 ha of agricultural land and posses 1.1 tropical livestock units. Cooperative members own significantly more land and have significantly more livestock than non-cooperative members.

Table 2. Comparison of farm and farmer characteristics across treated and control households

	Total sample (n=389)	Control households (n=235)	Treated households (n=154)
Female single headed (dummy)	22%	25%	11%*
HH head age (years)	45.6	44.6	49.0*
	(13.3)	(13.6)	(11.7)
HH head education (yrs)	4.9	4.7	5.4
	(2.9)	(2.7)	(3.3)
HH size agricultural workers (#)	1.9	1.8	2.4***
	(0.98)	(0.88)	(1.2)
HH size children (#)	2.5	2.6	2.4
	(1.7)	(1.7)	(1.8)
Land individually owned (ha)	0.27	0.25	0.34
	(0.50)	(0.48)	(0.54)
Livestock (TLU)	1.1	0.8	1.8***
	(1.1)	(0.9)	(1.5)
Distance to the market (min)	47	46	49
	(33)	(32)	(37)
Siblings (in law) living close (#)	2.2	2.1	2.5
	(2.5)	(2.5)	(2.5)

Notes: Mean values are shown, for continuous variables standard deviations are shown in parentheses. Treated households include households who are member of land and marketing cooperatives and control households include household that are not member of such cooperatives. Treated households are compared control households using t-test, *, ** and *** denote 10, 5 and 1% significance level.
(Source: calculations based on data from own household survey, 2012)

4.2. Probability of cooperative membership

The results of the probit model that calculates the PS and estimates the probability of cooperative membership is presented in Table 3. We find that households with a higher educated household head and households with more agricultural labor force have a higher probability of being member in a land and marketing cooperative. For example, one additional household member involved in agricultural production increases the likelihood of participation with 7.2% points. Further, households that own less land are more likely to be a member. Being located further away from the market has a significant negative effect on the probability of cooperative membership. Thus, more remote households who are generally confronted with higher transaction costs (and for whom cooperative marketing might be more beneficial) are less likely to participate in a cooperative. We find no effect indicating that single female-headed households have a significantly higher or lower probability of being member. The probability of being a member is not increasing or decreasing with age of the household head or with the social capital measure.

Table 3. Probit model results of factors determining cooperative membership

Variables	marginal effects	standard errors
Female single HH	-0.058	(0.062)
HH head age (yrs)	0.007	(0.013)
Square of HH head age	0.000	(0.000)
HH head education (yrs)	0.022***	(0.007)
HH agricultural workers (#)	0.072***	(0.024)
HH children (#)	-0.024	(0.015)
Land owned (ha)	-0.19**	(0.09)
Square of land owned	0.033	(0.022)
TLU	0.091***	(0.020)
Distance to the market (min)	-0.002**	(0.001)
Siblings close (#)	0.001	(0.011)
Pseudo-R^2	0.118	
LR chi2 (11)	61.8	
Prob > chi2	0.0000	
Observations	389	

Note: *, ** and *** denote 10, 5 and 1% significance level, respectively.
Estimated marginal effects are reported. Standard errors are shown in parentheses.
(Source: calculations based on data from own household survey, 2012)

5. Welfare impact of cooperative membership

5.1. Welfare differences between cooperative members and non-members

Member and non-member households differ substantially with respect to the different welfare indicators (Table 4). Income from farming is significantly higher for cooperative members – 400,422 RWF compared to 176,682 RWF for non-members. Also total household income and total household income per adult equivalent is significantly higher for treated household than for control households. While 34% of the cooperative member households is classified to be poor, the incidence of poverty is significantly higher (54%) among non-member households.

Table 4. Comparison of income and poverty across treated and control household

	Total sample (n=389)	Control households (n=235)	Treated households (n=154)
Farm income (RWF)	229,529	176,682	400,422**
	(307,653)	(194,161)	(491,565)
Total household income (RWF)	493,485	437,947	673,081**
	(643,687)	(628,527)	(661,998)
Income per adult equivalent (RWF)	111,036	99,240	149,183***
	(110,543)	(99,663)	(133,528)
Poverty	49%	54%	34%**

Notes: Mean values are shown, for continuous variables standard deviations are shown in parentheses.
Treated household include households who are member of land and marketing cooperatives and control households include household that are not member of such cooperatives. Treated households are compared control households using t-test, *, ** and *** denote 10, 5 and 1% significance level.
Annual farm income is calculated as the value of crop and livestock production (including non-marketed produce valued at market prices) minus variable production costs (including purchased inputs, hired labor, land rent, etc.). Revenue transfers from the cooperatives are also added to the farm income while cooperative contribution cost are subtracted. The poverty line is set at 83,000 RWF per adult equivalent per year, which is the Rwandan national poverty line for extreme poverty derived from the 2011 EICV3 survey.
(Source: calculations based on data from own household survey, 2012)

Using PS matching methods and calculating average treatment effects, we further analyze whether the observed differences in farm income, household income, and poverty between cooperative member and non-member households can be (partially) attributed to the impact of cooperative membership.

5.2. Average treatment effects

The estimated average treatment effects are presented in Table 5. A first important observation is that the estimated ATE's are consistent over different matching techniques. The estimated treatment effects of cooperative membership on households' farm income, total household income and household income per adult equivalent are significantly positive and similar in magnitude across the matching methods. The estimated treatment effect on the likelihood of being poor is significantly negative and similar in magnitude across the matching methods. These results point to robust estimates and imply that membership in land and marketing cooperatives is effective to improve farmers' welfare.

The estimated effect of cooperative membership on farm income ranges from 40% to 46%. Further we find that participation in a cooperative increases total household income with about one fifth to one fourth (estimated effects range from 22% to 24%) and income per adult equivalent with about one third (estimated effects range from 28% to 34%). We find that cooperative membership has a significant impact on the reduction of poverty; the likelihood of being poor decreases with 10 to 14% points.

Table 5. Estimated treatment effects (ATE) using different matching techniques

Dependent variables	Nearest neighbour Matching (1)	Nearest neighbour Matching (3)	Kernel Matching	Local linear Matching
log (farm income)	0.43***	0.40***	0.40***	0.46***
	(0.15)	(0.16)	(0.14)	(0.14)
log(total HH income)	0.24**	0.24**	0.22**	0.24**
	(0.11)	(0.12)	(0.10)	(0.11)
log(total HH income per ADEQ)	0.34***	0.32***	0.28**	0.32***
	(0.12)	(0.11)	(0.12)	(0.11)
Poverty	-0.10**	-0.14**	-0.12**	-0.13**
	(0.050)	(0.069)	(0.056)	(0.055)

Notes: Standard errors are shown in parentheses. Significant effects are indicated with * : $p \leq 0.1$; ** : $p \leq 0.05$; *** : $p \leq 0.01$. Total number of observations is 389, of which 235 control households and 154 treated households. (Source: calculations based on data from own household survey, 2012)

A visual inspection of the histogram and kernel density plot for the propensity score distribution for treated control households shows that there is sufficient overlap in the distribution between treated and control observations (Annex 1, Figure A 1.1 a and b). We verify the balancing properties by testing the equality of means between treated and (matched)

controls. The results of these tests show that there is no problem of unbalanced covariates after matching (Annex 1, Table A1.1). For the simulation based sensitivity analysis, we use a neutral confounder and a confounder calibrated to mimic the observable binary covariate female-headed household, as additional matching factors. The results indicate that the estimates with binary confounders differ less than 2.1% from the baseline matching estimators. These results indicate that our propensity score matching estimators are robust to violations of the conditional independence assumption (Annex 1, Table A 1.2).

6. Heterogeneous treatment effects

In this section we report and describe the results of the statistical and graphical analysis of heterogeneous treatment effects. This includes results of a linear regression model in which the estimated ATE is regressed on specific farm and farmer characteristics and a plot of this regression. We report results consecutively for different farm and farmer characteristics.

6.1. Heterogeneity over land ownership

From Figure 1, we find that the ATE of cooperative membership on total household income, income per adult equivalent and poverty is increasing with households' land holdings[3].

For total household income and income per adult equivalent the impact of cooperative membership is increasing with land ownership. We further find that land ownership has an inverse U-shaped effect on the impact of cooperative membership on farm income with a maximum at 0.54 ha. As about 82% of the households in the population have less than 0.54 ha of land this means that the farm income generating effect of cooperative membership largely increases with land holdings and that land and marketing cooperatives are found to be most effective for 'medium scaled' farmers. For households with more land, an additional increase in the amount of land owned is reducing the effect of cooperative membership on farm income. Our results contrast with previous findings of Ito et al. (2012) and Fischer and Qaim (2012a) demonstrating larger impacts of cooperative membership for smaller farm. These authors find evidence of a negative selection as the benefits of cooperative membership in

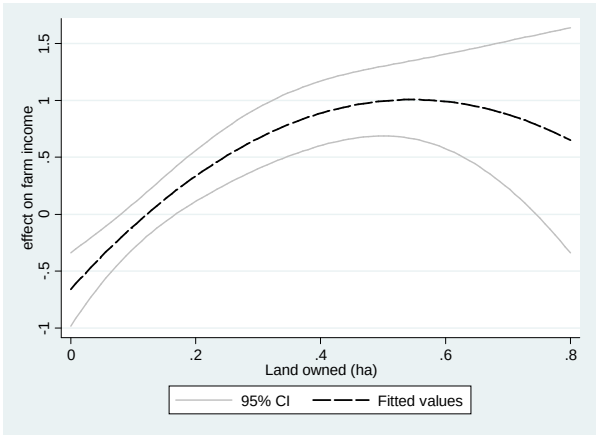
[3] We restricted the analysis for this variable to households with land holdings below 0.85 hectares, representing 92% of the households in the population. Full sample analysis did not result in substantial differences. However, the confidence intervals are very wide at the right hand side of the graphs and the maxima are positioned in the upper deciles of the land variable. To capture the behavior of the impact of cooperative membership for smaller (and representative) households we use a restricted sample of households with land holdings below 0.85 hectares.

terms of increased farm income were more pronounced for small farmers who also had a lower propensity to be member. These studies, however, looked at differences in effects across subgroups, while in this study the whole distribution of the effect over the land ownership variable is assessed. Further, land holdings in Rwanda are very small and with 82% of the households having less than 0.54 ha of land our results indicate that the cooperatives are not very effective for the poorest or near landless households. In our study, households with larger land holdings are found to have a lower probability to participate in cooperatives while the effect of an increased farm income is more pronounced for them (see Section 4).

For poverty, the land variable has a significant and downward sloping linear effect on the impact of cooperative membership. This means that the poverty reducing effect of cooperative membership increases with land ownership. In line with the heterogeneous impact on income, we find that the poverty reducing effect of cooperative membership is very small for households with little land (despite their access to the cooperative marshland). Hence, from a policy point of view, it makes little sense to target near landless households and make marketing cooperatives more inclusive towards them. For land-poor households to move out of poverty, other programs and policies are necessary.

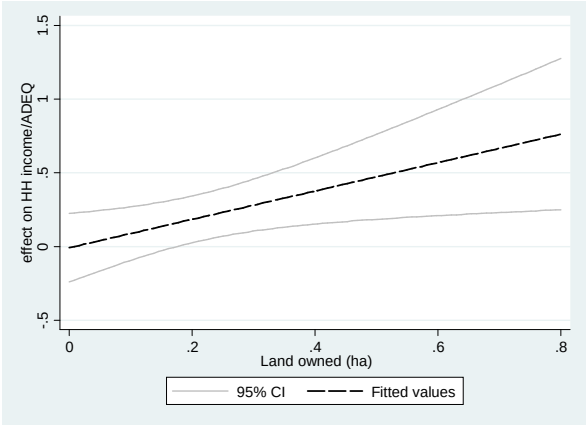
Figure 1: Heterogeneity of treatment effects over land holdings (farm size)

a) ATT on farm income



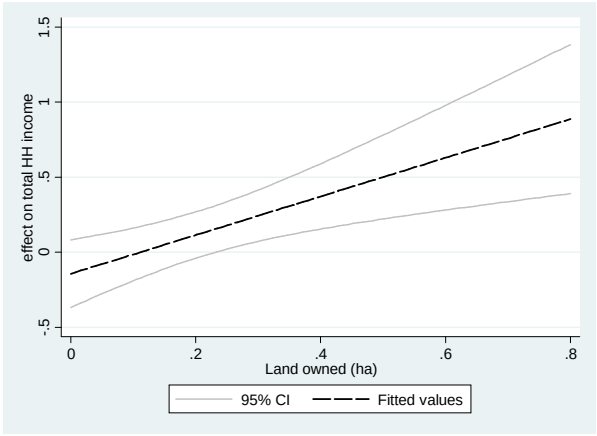
$$ATT = -5.57^{***}x^2 + 6.09^{***}x - 0.66^{***}$$

b) ATT on income per adult equivalent



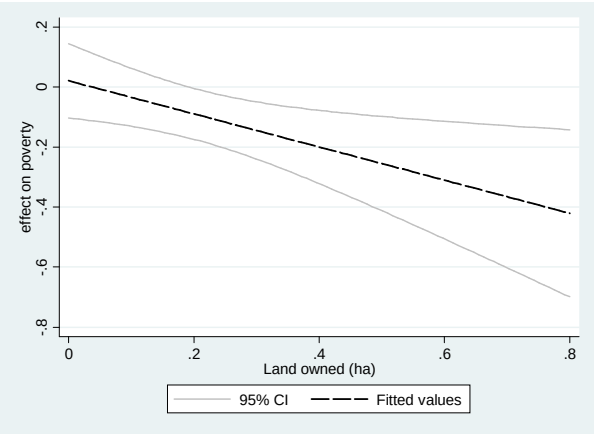
$$ATT = 0.96^{**}x - 0.008$$

c) ATT on total household income



$$ATT = 1.30^{***}x - 0.15$$

d) ATT on poverty



$$ATT = -0.55^{***}x + 0.022$$

Notes: Linear and quadratic prediction plots with 95% confidence intervals.

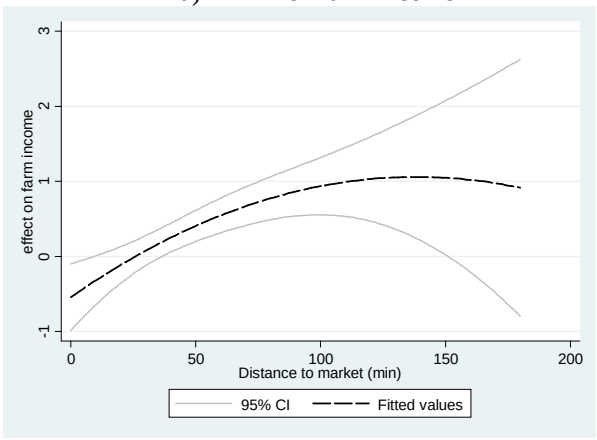
6.2. Heterogeneity over market access

Whether a household is living closer or further away from the market significantly affects the impact of cooperative membership on farm income, total household income and the likelihood of being poor (Figure 2). We find an inverse U-shaped effect of distance to the market on the estimated ATE for farm income, with a turning point at 116 minutes walking from the market. This is in line with the finding of Adebaw and Haile (2013) that there is an inverse U-shaped effect of distance to the nearest road on the impact of cooperative membership on technology adoption. For total household income and income per adult equivalent the estimated ATE is increasing with distance to the market. A similar trend is observed for the ATE on the likelihood to be poor.

The heterogeneity in impact according to distance to the market, validates a negative selection hypothesis and has important policy implications. As discussed in Section 4, more remote households have a lower propensity to be member of land and marketing cooperatives. However, at the same time these are the households that can achieve the largest welfare gains from cooperative membership. More remote farm households, experiencing more difficulties and/or costs to enter the market, benefit more from the transaction cost-reducing effect of cooperative membership but at the same time the difficulties and/or costs to enter a cooperative are more pronounced for them. The combination of these two findings indicate that, from a policy perspective, it is important to stimulate cooperative formation in more remote areas as the potential impact in those areas is larger.

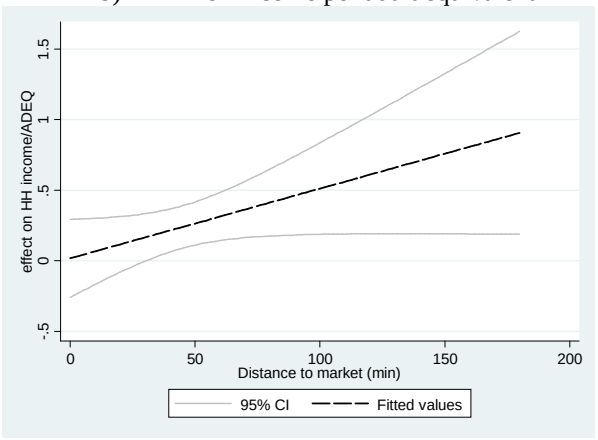
Figure 2: Heterogeneity of treatment effects over market access (distance to the market)

a) ATT on farm income



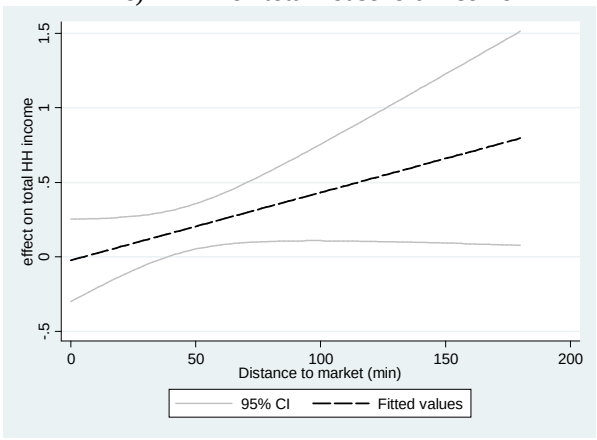
$$ATT = -0.001^{*}x^{2} + 0.023^{***}x - 0.54^{**}$$

b) ATT on income per adult equivalent



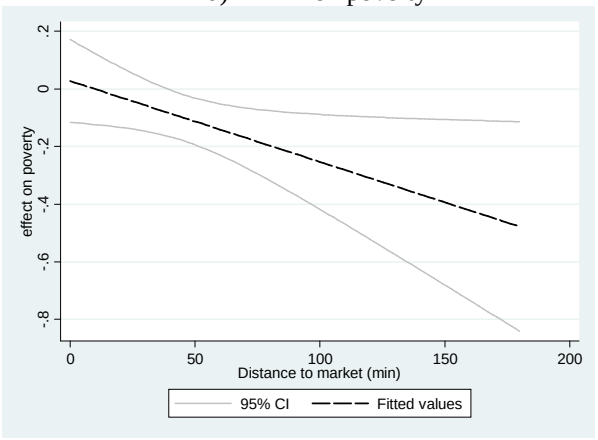
$$ATT = 0.005^{*}x + 0.14$$

c) ATT on total household income



$$ATT = 0.0045^{*}x - 0.024$$

d) ATT on poverty



$$ATT = -0.0028^{**}x + 0.073$$

Notes: Linear and quadratic prediction plots with 95% confidence intervals.

6.3. Heterogeneity over demographic characteristics

None of the considered demographic characteristics – age and education of the household head, and the available agricultural labor force – have an impact on the estimated impact of cooperative membership on farm income (see figures in Annex 2). Yet, the impact on total household income does depend on the household demographic characteristics. We find that labor availability and education have a positive effect on the estimated ATT. For labor availability, we find a U-shaped effect with a minimum at 3.3 agricultural workers in the household. As the large majority of households in the sample (about 95%) have at least three agricultural workers, we can interpret this as an increasing effect. Given that also the probability to be a cooperative member increases with labor availability and education, these results imply that there is a bias in the (self-)selection of households into cooperatives towards larger and more educated farm-households because those households retract the largest gains in terms of increased incomes from cooperative membership. This is not completely in line with the findings of Bernard et al. (2008) who find no significant different impact of cooperative membership according to education, and of Adebaw and Haile (2013) who report a decreasing impact of cooperative membership with an increasing level of education.

Further, age has a significant positive but decreasing effect on the estimated ATT on total household income, with a maximum at around 52 years. In addition, the results indicate that the poverty reducing effect of cooperative membership is decreasing with the amount of agricultural workers. The highest poverty reducing impact is found for households that have fewer agricultural laborers – likely because these are the poorest households, not because the income gains are largest for these households.

We further find that there is no differential impact of cooperative membership for female single headed households[4]. This is in line with the findings of Adebaw and Haile (2013) and confirms that the impact of cooperative membership does not change according to the gender of the household head. The results in section 4 also show no gender selection in the likelihood of being a member in the land and marketing cooperatives. The fact that there is no gender bias in cooperative membership is an important finding as about one fourth to one fifth of farm households in the research region are single female-headed households.

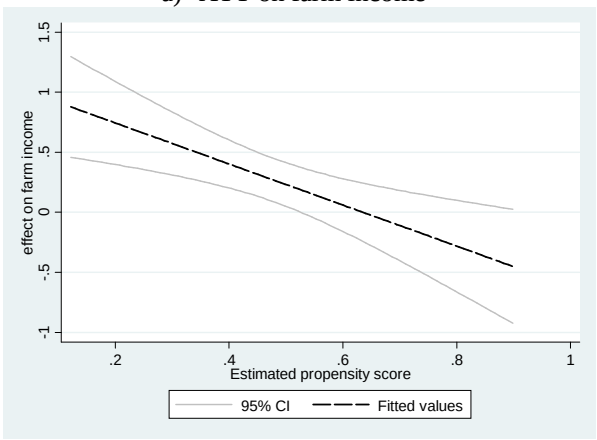
[4] The impact of the cooperative membership on single female headed households is compared with the impact on other households' outcome variables using t-test. No significant differences are found (Test results for ATT on farm income: t= -0.066 and p= 0.95, test results for ATT on total household income: t= 1.22 and p= 0.22, test results for ATT on income per adult equivalent: t= -0.52 and p= 0.61, test results for ATT on poverty: t= 0.59 and p= 0.56).

6.4. Heterogeneity over the propensity to be a cooperative member

An additional point to consider is whether the impact of cooperative membership on household welfare differs with the propensity of being a cooperative member. To address this question we analyze the impact of the membership over households' corresponding propensity score (Figure 3).

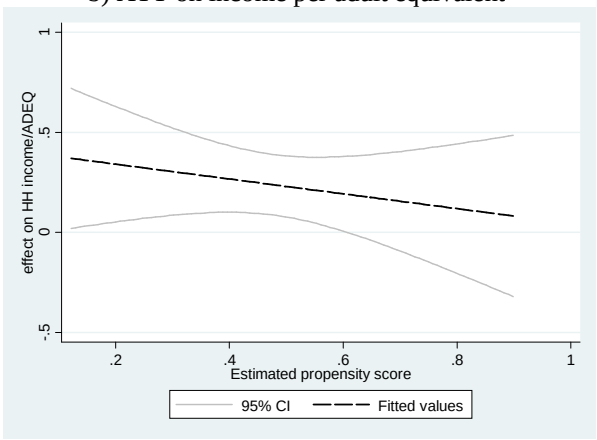
Figure 3: Heterogeneity of treatment effects over the propensity to be a cooperative member

a) ATT on farm income



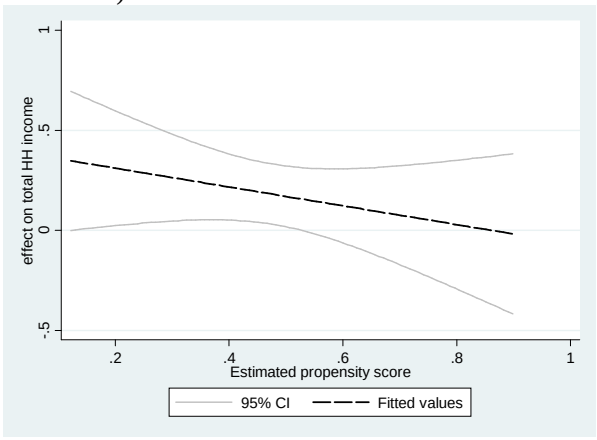
$$ATT = -1.71^{***}x + 1.09^{***}$$

b) ATT on income per adult equivalent



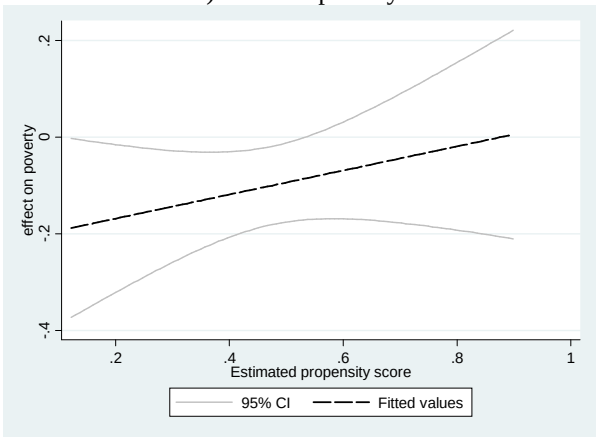
$$ATT = -0.37x + 0.42^{*}$$

a) ATT on total household income



$$ATT = -0.47x + 0.41^{*}$$

b) ATT on poverty



$$ATT = 0.25x - 0.22^{*}$$

Notes: Linear and quadratic prediction plots with 95% confidence intervals.

We do not find a significant effect of the propensity to be a cooperative member on the impact membership has on total income, the income per adult equivalent, and the probability of being poor. For farm income, we observe a significant downward sloping effect. This indicates that the impact of cooperative membership is decreasing as a household has a higher probability of being member in that cooperative.

7. Conclusions and policy implications

In Rwanda, agricultural cooperatives are seen as an important institutional vehicle to spur agricultural development and reduce rural poverty through intensification and specialization of the smallholder farm sector. For such institutions to have an impact on poverty, they need to be inclusive – i.e. poorer farmers need to be able to participate – and effective – i.e. they need to have an impact on the incomes and wellbeing of participating farmers. In this paper we analyzed the effectiveness of land and marketing cooperatives in Rwanda to improve farmers' welfare and reduce rural poverty by analyzing farm-households' inclusion into cooperatives, the welfare impacts of cooperative membership, and the heterogeneity in impact across farm and farmer characteristics.

Our results show that land and marketing cooperatives in Rwanda are to some extent exclusive. We find that a higher education of the household head and a higher number of workers in the household increase the probability of cooperative membership which indicates that some households are constrained to participate due to a lack of human capital. Also remoteness is a constraint for cooperative membership. Yet, we do find that cooperatives are effective in improving rural incomes and reducing rural poverty. Our results show that cooperative membership has significant positive effects on farm and total household income; and significant negative effects on the likelihood of being poor. The average effects are quite large, with cooperative membership increasing farm income with about 40 to 45%, increasing total household income with about one fifth to one fourth and increasing the income per adult equivalent with about one third. The likelihood of being poor is reduced with 10 to 14% points. For a population in which 49% of the households are poor these are important effects

From a policy perspective, the results of this study give valuable insights in the inclusiveness and effectiveness of agricultural cooperatives in Rwanda. Although significant positive average treatments of cooperative membership are found on households' income and poverty reduction, studying the heterogeneity in this treatment effects reveals that cooperative membership might not be an effective strategy for the poorest-of-the-poor. Although we did not find an exclusion towards these land-poor households, cooperative membership has little effect on their income and likelihood of being poor. From a policy point of view it then makes little sense to focus on the inclusion of the poorest of the poor (in terms of land) in this kind of cooperatives. To lead these land poor-households out of poverty other programs and policies should be in place. We do not find evidence for an exclusion (or inclusion) bias towards

female single headed households. Also the results of the impact heterogeneity analysis did not reveal a different effect of cooperative membership for single female-headed households. The finding that there is no gender bias in cooperative membership and its impact is a welcoming finding as about one fourth to one fifth of the rural farmer households in the research region are single female headed households and it indicates that in the case of cooperatives no special (re)targeting towards these kinds of households is needed. Finding that more remote households are less likely to be a cooperative member suggests that these households have particular entry difficulties and/or costs for cooperative membership. However as these more remote farm households are benefitting more from cooperative membership, possibly through transaction cost-reducing effects, it calls for renewed initiatives to stimulate cooperative formation in more remote areas and to reduce initial participation constraints.

Finally, we need to recognize the limitations of our case study. The framework in which cooperatives in Rwanda originated and are working is rather particular and one should be careful regarding the generalization of their effects. The results of our study are challenging some prevailing judgments about cooperative formation and agricultural transformation in Rwanda. We hope that this will stimulate further multidisciplinary research to follow evolutions in the smallholders' farm sector in Rwanda. This work also highlights the importance to look beyond average (treatment) effects and study the heterogeneity in effects.

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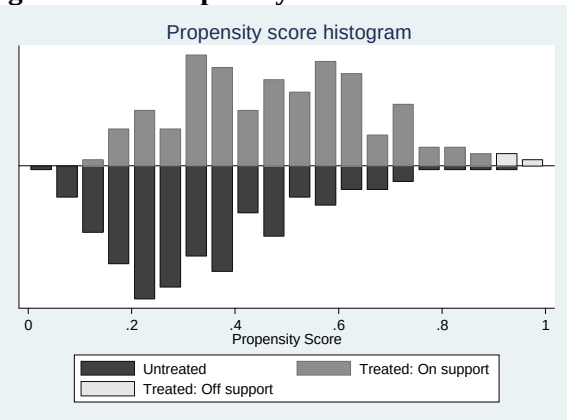
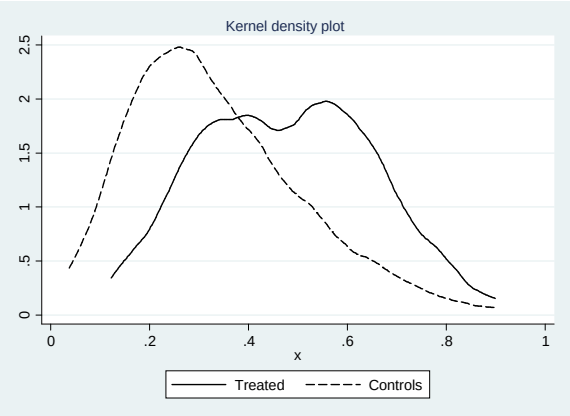
Annex 1: Robustness checks for kernel PS matching

Figure A 1.1: Propensity score distribution



a. Histogram



b. Kernel density plot

(Source: calculations based on data from own household survey, 2012)

Table A1.1. Balancing properties of covariates in treated and control groups for kernel matching

Covariates	Sample	Mean treated units	Mean control units	% Bias between treated and controls	% Reduction in bias	t-test Mean(treated) = Mean (controls)
Female single HH	Unmatched	0.195	0.244	-11.8		-1.12
	Matched	0.199	0.182	4.1	65.1	0.37
HH head age (yrs)	Unmatched	51.4	46.1	43.3		4.13***
	Matched	51.2	50.9	2.3	94.6	0.20
Square of HH head age	Unmatched	2,788	2,271	41.3		3.98***
	Matched	2,775	2,743	2.6	93.7	0.21
HH head education (yrs)	Unmatched	5.14	4.27	25.4		2.43**
	Matched	5.06	5.08	-0.6	97.6	-0.05
HH agricultural workers (#)	Unmatched	2.50	2.11	35.9		3.47***
	Matched	2.47	2.53	-5.4	84.9	-0.44
HH children (#)	Unmatched	2.33	2.49	-9.5		-0.90
	Matched	2.34	2.42	-4.7	50.4	-0.41
Land owned (ha)	Unmatched	37.4	36.2	2.1		0.20
	Matched	37.9	43.8	-9.6	-364.5	-0.76
Square of land owned	Unmatched	4,995	5,216	-0.9		-0.09
	Matched	5,081	6,909	-7.8	-727.4	-0.63
TLU	Unmatched	1.60	1.09	43.8		4.25***
	Matched	1.56	1.57	-0.8	98.1	-0.07
Distance to the market (min)	Unmatched	43.9	51.5	-24.5		-2.32**
	Matched	44.7	45.1	-1.2	95.1	-0.11
Siblings close by (#)	Unmatched	2.13	2.22	-3.7		-0.35
	Matched	2.14	2.36	-9.5	-160.9	-0.80

Note: *, ** and *** denote 10, 5 and 1% significance level, respectively
(Source: calculations based on data from own household survey, 2012)

Table A1.2. Simulation-based sensitivity analysis for kernel PS matching estimators

	Neutral Confounder			Confounder calibrated to mimic dummy for female headed households		
Dependent variables	Estimator effect[a]	Outcome effect[b]	Selection effect[c]	Estimator effect[a]	Outcome effect[b]	Selection effect[c]
log (farm income)	1.6%	1.02	1.06	1.6%	0.545	0.78
log (total household income)	-1.6%	1.00	1.00	2.1%	0.58	0.73
log (total household income/ADEQ)	0.8%	1.06	1.01	0.4%	1.09	0.82
Poverty	0.0%	1.02	1.05	-1.0%	0.86	0.74

[a] The estimator effect indicates to what extend the baseline estimation result would change if we could observe an additional binary confounder

[b] The outcome effect measures the estimated effect of the simulated binary confounder on the dependent variables

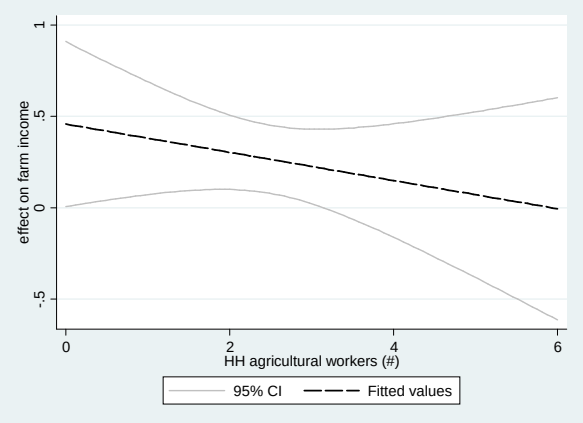
[c] The selection effect measures the estimated effect of the simulated binary confounder on the selection into treatment, this is the propensity of being a treated household

(Source: calculations based on data from own household survey, 2012)

Annex 2: Heterogeneity of treatment effects over demographic characteristics

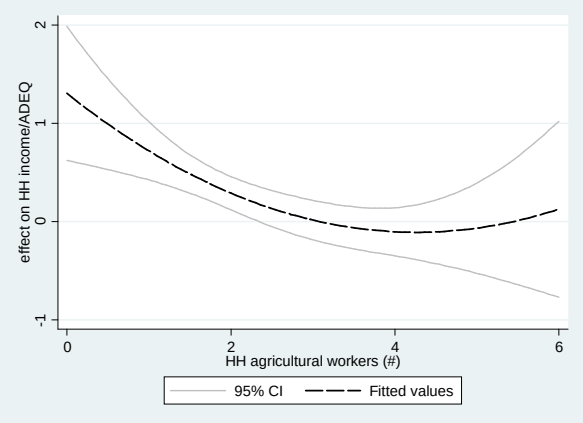
Figure A2.1: Heterogeneity of treatment effects over agricultural labor force

a) ATT on farm income



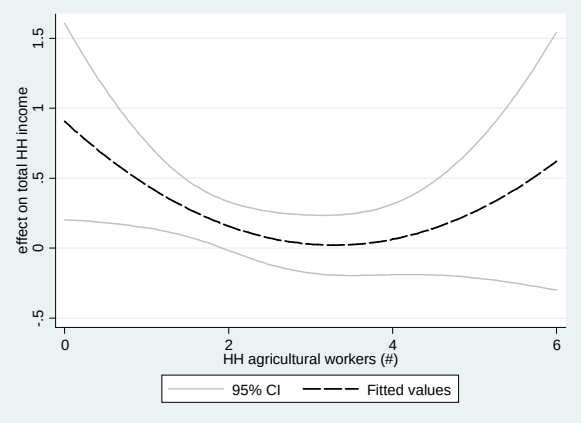
$$ATT = 0.077\,x + 0.46^{**}$$

b) ATT on income per adult equivalent



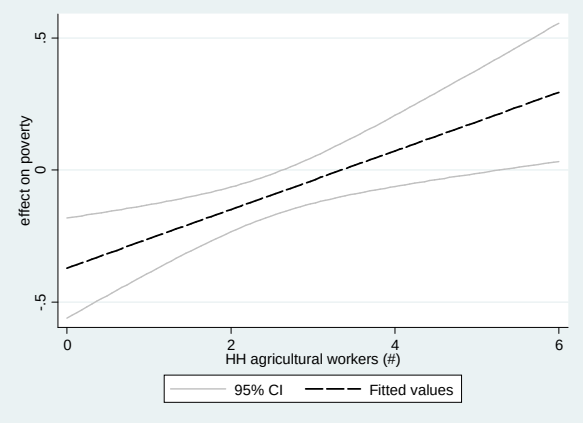
$$ATT = 0.078^{*}x^{2} - 0.66^{**}x + 1.30$$

b) ATT on total household income



$$ATT = 0.082^{*}x^{2} - 0.54^{**}x + 0.91^{**}$$

d) ATT on poverty

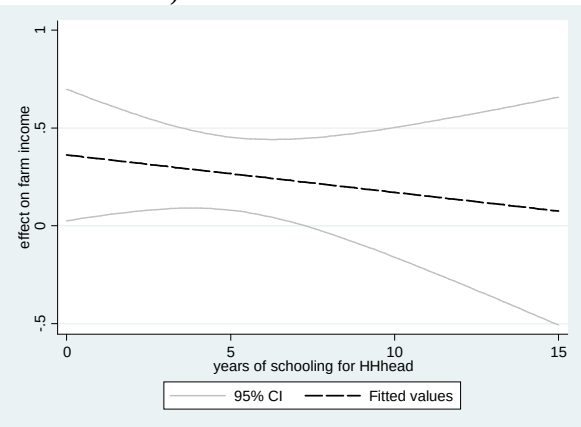


$$ATT = 0.11^{***}x - 0.37^{***}$$

Notes: Linear and quadratic prediction plots with 95% confidence intervals.

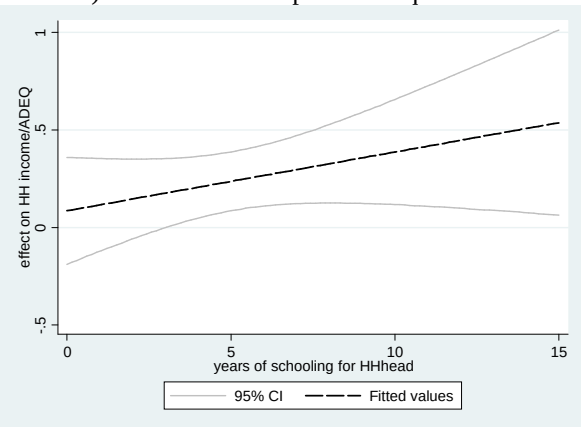
Figure A2.2: Heterogeneity of treatment effects over farmers' education

a) ATT on farm income



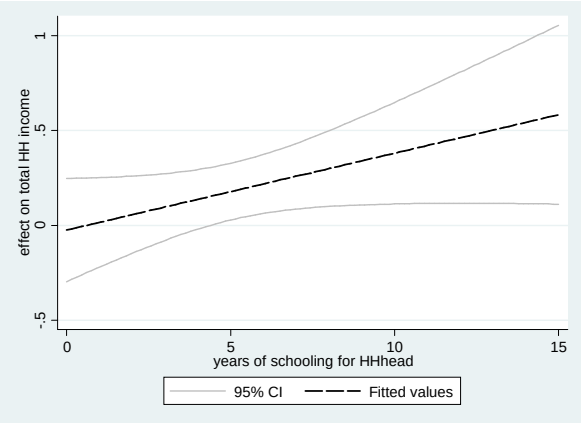
$$ATT = -0.019x - 0.36^{**}$$

b) ATT on income per adult equivalent



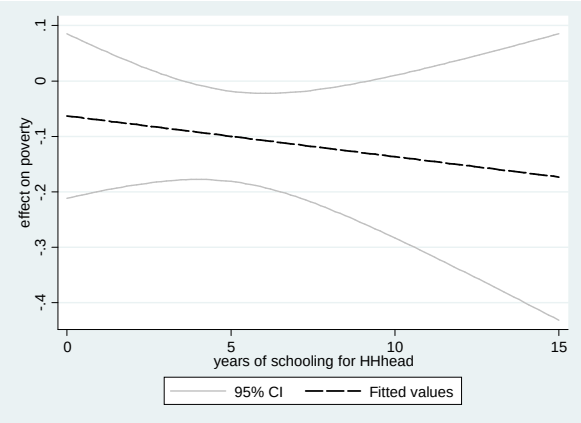
$$ATT = 0.030x + 0.086$$

c) ATT on total household income



$$ATT = 0.041^{*}x - 0.025$$

d) ATT on poverty

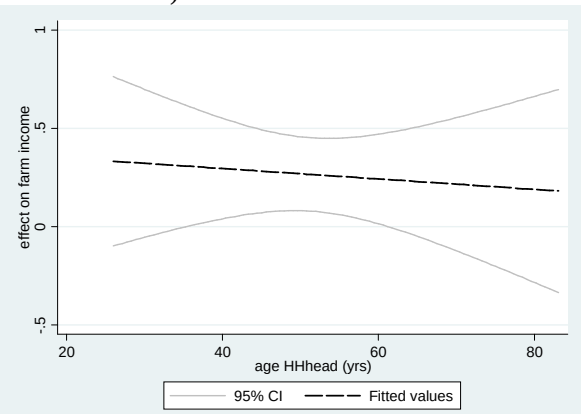


$$ATT = -0.0073x - 0.063$$

Notes: Linear and quadratic prediction plots with 95% confidence intervals.

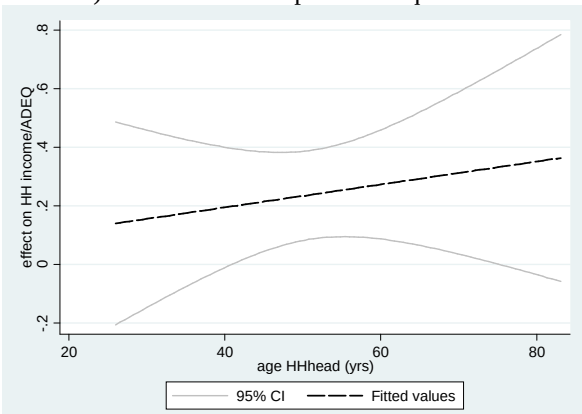
Figure A2.3: Heterogeneity of treatment effects over farmers' age

a) ATT on farm income



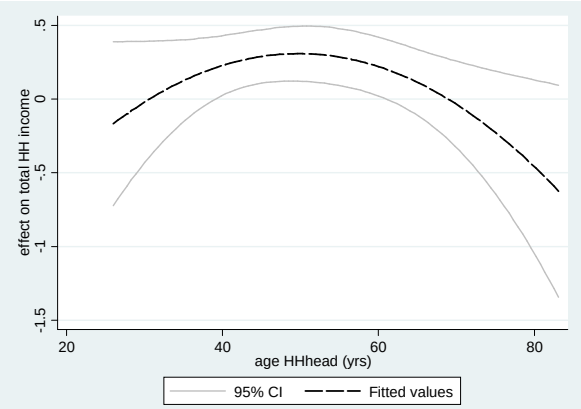
$$ATT = -0.0027x + 0.40$$

b) ATT on income per adult equivalent



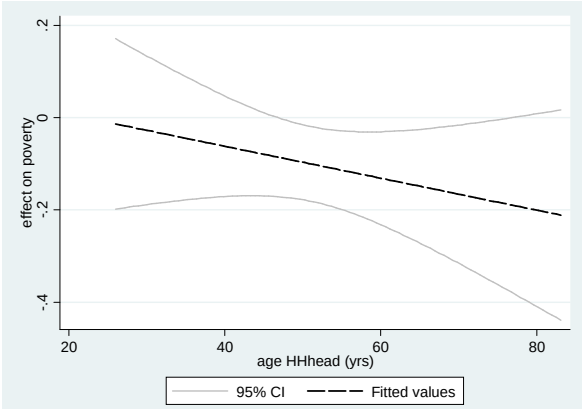
$$ATT = 0.004x + 0.038$$

c) ATT on total household income



$$ATT = -0.0008^{**}x^2 + 0.084^{***}x - 1.77$$

d) ATT on poverty



$$ATT = -0.0035x + 0.076$$

Notes: Linear and quadratic prediction plots with 95% confidence intervals.

Chapter 6

General conclusions

Food production and trade in developing countries is highly influenced by the modernization of food value chains but there is no consensus (yet) on the overall welfare implications. In this dissertation, we focus on institutional innovations in food supply chains and analyze the rural development implications of vertical and horizontal coordination in food supply chains in Senegal and Rwanda. Doing so, we increase the understanding of the multiple dimensions of food value chains, their performance and their development implications.

Concerning vertical coordination, empirical studies mostly focused on the inclusiveness and effectiveness of contract farming schemes, an intermediate form of vertical coordination. A global trend of increased vertical integration, however, creates additional employment opportunities for rural households causing labor market effects to become more important. Few studies have looked at the indirect effects of this increased rural employment opportunities.

In this dissertation, we consider a case study in Senegal and analyze the indirect effect of the boom in horticultural exports and the related increase of rural employment on child schooling. The export boom has caused a dramatic increase in female off-farm wage employment in the export companies, which led to increased female bargaining power in the household. We investigate the causal effect of female wage income on primary school enrolment. We find that female off-farm wage income has a positive effect on primary school enrolment. For example, female wage employment increases the likelihood of primary school aged children to be enrolled in school with 26% points, an effect that is found to be equally large for both boys and girls. Further, we demonstrate that female empowerment is specifically important for the schooling of girls.

Besides the welfare effects of horticulture export through product markets, important effects emerge through labor markets as well. Our results demonstrate that indirect effects are important and should be considered when the effects of high-value exports are evaluated. Finding that rural women can be empowered through participation in the labor market and that empowering women benefits school enrolment rates, calls for attention to labor markets in policy strategies on gender and education. Apart from the female wage employment, also

parental education and the wealth position of households were found to be important determinants of primary school enrolment. These results stress the importance of demand factors increasing school enrollment rates and make clear that governmental education programs that focus only on the supply side of schooling are not sufficient.

The existing literature on food supply chains mostly focuses on higher-value and global food supply chains, like export chains or chains dominated by FDI and large supermarkets. However, the landscape of food value chains is more diverse than the typical dichotomous distinction between so called ‘modern’ and ‘traditional’ food value chains. In chapter 3, we conduct a value chain analysis of horticultural value chains in Rwanda. We show that a wide variety of horticultural supply chains exist in the country and argue that value chains can be differentiated beyond the current dichotomy of global (modern) chains versus local (traditional) chains. Processes of modernization, especially value-adding, quality differentiation and vertical coordination, also take place in domestic and local chains.

In the context of food value chains the effects of horizontal coordination processes at producer level resulting in the establishment of professional producer cooperatives, have rarely been analyzed. The literature on recent food value chain innovations and their development implications mostly focuses on the vertical coordination processes. In chapter 4, we analyze the direct effects of participation in cooperatives on agricultural performance for rural households in Rwanda. Agricultural policies in Rwanda focus on agricultural intensification and increased market orientation of the smallholder farm sector. Cooperatives are seen as key vehicles in this, but little is known about their effectiveness to achieve these goals.

Unlike most impact studies that focus on a single cooperative or on multiple cooperatives in a single sub-sector, we explicitly look at the diversity in cooperatives and analyze the role of cooperative structure and organizational differences to explain impact heterogeneity across different cooperatives. We find that cooperative membership in general has a positive impact on different farm performance indicators. Participation in a cooperative improves market orientation as it increases the share of farm produce sold with 10 to 16% points. Cooperative membership also results in increased agricultural intensification as it increases the value of inputs used with 6 to 8.6 thousand RWF, and the likelihood of using improved seeds, mineral fertilizer, pesticides and irrigation increases with about 21 to 31% points. Cooperative membership further increases gross farm revenue with 37% and net farm income with 25%.

However, these effects are driven by specific types of cooperatives. We find the largest effects for cooperatives in which farmers' incentives are least distorted, i.e. cooperatives that focus on joint input acquisition and marketing and cooperatives in which remuneration is individually based.

Further, we use the Rwandan case and analyze both inclusiveness and effectiveness of agricultural cooperatives (chapter 5). We find that cooperative membership in general increases income and reduces poverty. Cooperative membership increases total household income with about one fifth to one fourth and reduces the likelihood of being poor with 10 to 14% points. The evaluation of the impact heterogeneity across farmers shows that these effects are largest for larger farms and in more remote areas. Considering the inclusiveness and effectiveness of the cooperatives simultaneously, we find evidence of a negative selection as the impact is largest for farmers with the lowest propensity to be a cooperative member.

The results of our case study on cooperatives in Rwanda are challenging some prevailing judgments about cooperative formation and agricultural transformation. The results from chapter 4 point out that both cooperatives involved in lower-value staple food sectors as well as in higher-value horticulture sectors can contribute to the modernization of the smallholder farm sector and improve farmers' income. Our results do not support the popular point of view that cooperatives create the highest value for higher-value horticulture crops. We find that positive effects of cooperative membership are mainly found for cooperatives that focus on cooperative marketing, cooperative input supply and land acquisition, with remuneration systems that are in line with individual farm-household incentives. From a program and policy point of view, one should be cautious establishing cooperatives in which agricultural production is organized in a communal way and a collective payment systems is installed. The results from chapter 5 have important policy implications as well. Although positive effects of cooperative membership are found on households' income and poverty reduction, the land and marketing cooperatives are to some extent exclusive and the heterogeneity in effects reveals that cooperative membership might not be an effective strategy for the poorest-of-the poor. For land-poor households cooperative membership has little effect on their income and their likelihood of being poor, so it makes little sense to focus on their inclusion; rather other programs and policies should be in place to lead these households out of poverty. We also find arguments for renewed initiatives to stimulate cooperative formation in more remote areas –as farm households in these areas are benefitting more from cooperative membership. However, as our results suggest that these households have particular entry difficulties and/or

costs for cooperative membership, initiatives for cooperative formation in remote areas should give special attention to reduce the initial participation constraints.

From a research perspective, our case-study results add to the empirical literature on innovations in and the performance of food supply chains, and on the development implications of supply chain upgrading.

To analyze the overall development implications of emerging food value chains it is necessary to distinguish between different effects. Besides knowing whether -and which type of- smallholders are included in or excluded from participation in product and/or labor markets, the effectiveness of this participation -i.e. whether a positive impact on farmers' income and wellbeing is created- needs to be studied as well. As most of the empirical studies looked at the direct effects of participation in product and labor markets, more research should focus on the occurrence of indirect effects and the channels through which these occur. In particular, the area with regard to health, nutritional outcomes and female empowerment, for example women's fertility or status at the marriage market, remains unexplored.

Further, the landscape of food value chains is diverse and goes beyond the current dichotomy of modern versus traditional chains. Most households in developing countries depend primarily on traditional domestic food value chains both for food provision, to sell their agricultural production, and as a source of employment. Traditional wet markets and local retailers, for example, will remain dominant aspects in domestic food retail in many developing countries and potential spillovers from modern value chains might result in greater economic gains and poverty reduction. New studies should not only focus on higher-value chains related to export markets or supermarkets, but rather take on an integral approach with attention to changes and processes in domestic and local value chains.

Studies on food value chain innovations and their development implications mostly focus on vertical coordination processes like contract farming and full ownership vertical integration. The results from our studies, however, indicate that inclusion in food value chains through producer organizations, a form of horizontal coordination, leads to significant positive effects on rural households' farm performance and overall welfare. These effects have mainly been associated with the development of high-value chains related to export and modern domestic retail. Based on the positive findings from our studies, we call for more research on the development and effects of horizontal coordination at producers' level.

Finally, more studies should start to investigate the potential heterogeneity in treatment effects. Examining heterogeneity in treatment effects stems from the program evaluation literature, for example the evaluation of development programs and public health programs, and implies that, beyond mean impact studies, the distribution of impacts within treated subjects is analyzed. Analyzing how the treatment effects vary within the population allows studying the combined effect of inclusion and effectiveness of a program or intervention and can increase the efficiency of program targeting by assigning eligibility to subjects that benefit most from the participation. There are a few studies, including our own, that analyzed impact heterogeneity for participants in rural producer groups. Despite the vast amount of studies related to the development of food value chains and their direct and indirect impacts, studies exploring the heterogeneity in these effects are missing. For example, new studies can look at the heterogeneity of the impact of contract farming or employment in export and agro-processing companies.

Summing up, we believe to touch on important elements for further food value chain research, including 1/ the need to look beyond mean treatment effects and investigate heterogeneous treatment effects; 2/ the need to look beyond direct effects and unravel indirect channels of impact; 3/ the need to look beyond contract farming as coordination mechanism in food supply chains and include horizontal coordination mechanism; and 4/ the need to expand our understanding of supply chain innovations to domestic and local food value chains in developing countries.